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CONTRACTOR REPORT ARPAD-CR-82001

ELECTROTHERMAL ANALYTICAL RESPONSE INSPECTION OF ELECTROEXPLOSIVE DEVICES

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MARCH 1982

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
PRODUCT ASSURANCE DIRECTORATE
DOVER, NEW JERSEY

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER
Contractor Report ARPAD-CR-82001

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
ELECTROTHERMAL ANALYTICAL RESPONSE INSPECTION OF ELECTROEXPLOSIVE DEVICES

5. TYPE OF REPORT & PERIOD COVERED
Final Report
June 1979 to December 1981

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
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Franklin Research Center
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8. CONTRACT OR GRANT NUMBER(s)
DAAK10-79-C-0134

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Franklin Research Center
20th Street and The Parkway
Philadelphia, PA 19103

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
D/A Project: M6350
ACMS Code: 53970M6350

11. CONTROLLING OFFICE NAME AND ADDRESS
ARRADCOM, TSD
STINFO Div (DRDAR-TSS)
Dover, NJ 07801

12. REPORT DATE
March 1982

13. NUMBER OF PAGES
138

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
ARRADCOM, PAD
Tech & Auto, Info & Math Div (DRDAR-QAS)
Dover, NJ 07801

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
This project has been accomplished as part of the U.S. Army Materials Testing Technology Program, which has for its objective the timely establishment of testing techniques, procedures or prototype equipment (in mechanical, chemical, or nondestructive testing) to insure efficient inspection methods for materiel/material procured or maintained by DARCOM.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Nondestructive testing
Electroexplosive devices
Electrothermal response

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
A commercial electrothermal tester and digital equipment were used to test SCD 10383 fuses and PA506 and M100 detonators nondestructively. Dissection and examination revealed positive faults on all types of devices tested (one each). Correlation was found between various NDT measured thermal parameters and sensitivity, burnout for fuses and fire/no fire results for detonators. The digital system that was developed represents a possible transition to on-line NDT of electroexplosive devices.

(cont)

20. ABSTRACT (cont)

The system could be set to accept or reject devices based on departure from preset limits. The main limitation on the detonator testing was created by a small coefficient of thermal resistance of the bridge wire material which resulted in a poor signal-to-noise ratio.

The system, if refined and used in production, would eliminate devices that are deficient in the bridge wire area. Comparisons with a collective thermal model indicate it would further permit culling of extremely sensitive or insensitive devices.

ACKNOWLEDGMENTS

This report reflects the efforts of numerous personnel who supplied Franklin Research Center with test materials, background information, and guidance in the related areas of the project. Noteworthy also is the invaluable support received from Professor L. A. Rosenthal of Rutgers University, who served as consultant to ARRADCOM.

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1. INTRODUCTION

Nondestructive testing (NDT) of wirebridge electroexplosive devices (EEDs) may seem a self-contradictory statement. EEDs are designed to work once; and in the process of working, they are destroyed. For nearly 25 years researchers have been unable to accept the existing quality assurance methods: on-line microscopic inspection, x-rays, N-rays and the other then-existent methods as the final word. An electrical-thermal feed-back from most wirebridged detonators express thermal conditions of the complete electroexplosive system. For this reason, it is one of the most sensitive tests of the electrical/explosive system that exists.

Further investigation seemed warranted by ARRADCOM, Dover, into the potential of this electrothermal test method for applications in product assurance in the production stages of EEDs. Success in this effort would permit questionable items to be detected and eliminated before their installation in critical weapon systems where the cost of failure is much higher in terms of lives and property.

Effort was concentrated on the measuring system, its safety and usefulness, and on electrical fuses (10383-30) and detonators (PA506 and M100).

This work was accomplished using commercially available equipment. The general approach was to seek the meaningfulness of the nondestructive test and its applicability to testing of electroexplosive devices.

Our findings are clear in some areas. The test is of great value for finding defects in wire bridged fuses, detonators, and probably in other EEDs. There are limitations, and there will need to be compromises in making measurements. Signal-to-noise levels are improved by using higher currents; but higher currents tend to reach into the range where some detonators are going to fire during nominal nondestructive tests. The effects of this problem can probably be circumvented by using proper safety precautions. Proper shielding of measuring stations to prevent explosive propagation will probably be necessary. Bridge wire materials with small thermal coefficients of resistance (α) are prone to provide little feedback and are therefore not amenable to electrothermal testing, except to detect certain defects in construction.

Overall, the system is useful enough to warrant some special choices of bridge wire material to make this kind of quality test possible; it is that important.

Application of this nondestructive test (NDT) to EEDs in the production stage is realizable. The system lends itself well to automatic methods with some study and design. The system can most probably be adapted to production lines where in-line inspection can be accomplished.

2. HISTORY AND THEORY

2.1 GENERAL HISTORY

Electric detonators were used as early as the Civil War. They were wired into cannon balls containing explosives. The ball was fired as usual, but a long trailing wire allowed an observer to fire the bursting charge in the cannon ball by touching the leads to a battery at an opportune time.

Today, one of the real advantages to EEDs, is that they serve to link the brains to the brawn, electronic computer controls to high explosives, thereby making most efficient use of explosive systems.

Not much improvement in EEDs was experienced until proximity fuzes were introduced in World War II. This was the first need for a link between an electronic device and a detonator. The need was critical and it is likely that great care was taken in product assurance on the electric detonator. This need exists even more critically today when so much hinges on the effectiveness of our weapons, when success depends upon having quality in electroexplosive devices.

Electrothermal testing of EEDs is not a new development. The Franklin Institute started investigating resistance changes in EEDs during the application of constant current pulses and characterized the change in resistance as a function of time and of current input in the 1950's. These findings were coupled with circuit theory to examine the aspect of non-linear responses of the resistance of detonators as part of a firing cirucit.[1] Further examination of EED responses to transient pulses was made and reported by the Navy.[2] This work dealt with the dynamic resistance of EEDs during pulse application.

NDT measurements were made by a method developed at FRC under the sponsorship of Picatinny Arsenal. FRC investigation involved the relationship between nondestructive measurements and the firing sensitivity of

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[1] Please refer to list of references at the end of this report.

electroexplosive devices (EEDs). [3] This research reached the point where it was applied to many EEDs with the expectation that some degree of correlation would be found between the constant current firing sensitivity and the electrothermal parameters that could be measured without degrading the EED.

The parameters that were measured were R_o (initial resistance) and $\Delta R/\Delta P$ (power sensitivity), where the latter is defined as the change in bridgewire resistance for a corresponding increase in input power. We found that a predictable inverse relationship exists between the product $R_o \Delta R/\Delta P$ and the current required to fire most EEDs. The current necessary to fire a wire bridge EED could often be estimated, on a relative basis, by measuring only R ; but a higher degree of correlation could be had by using the product $R_o \Delta R/\Delta P$ instead of R_o was that the former was able to detect abnormal thermal environments around the bridgewire such as the absence of the spot charge.

To classify a test as nondestructive, one must be able to make all measurements without altering or degrading the normal firing sensitivity of the test item. Past experience with several EEDs indicated that there were usually no changes in the normal firing sensitivity caused by measuring R_o or $\Delta R/\Delta P$ by the following procedure. Both R_o and $\Delta R/\Delta P$ are measured with a resistance bridge circuit shown in Figure 2-1, where X represents the device being tested, and the series resistors at A or B limit the current through the detonator to <u>1 milliampere</u>. When the bridge is balanced, R_o is recorded. The bridge is then unbalanced by increasing R_1 by a known amount (this is ΔR) and the current is increased to bring the bridge back into balance. The voltage drop across the detonator, due to this increased current, is measured and the power is computed, $P = \frac{E^2}{R_o + \Delta R}$. The change in power (ΔP) necessary to balance the circuit is actually the power necessary to balance the bridge for a known R minus the power necessary to measure R_o. The power needed to measure R_o is so small it is always neglected in these calculations.

The relationship which was found between R_o and the constant current sensitivity is given approximately by

$$\text{Cons. Cur. Sens.} = k_1 \frac{1}{\Delta R/\Delta P} + k_2,$$

where k_1 and k_2 are constants.

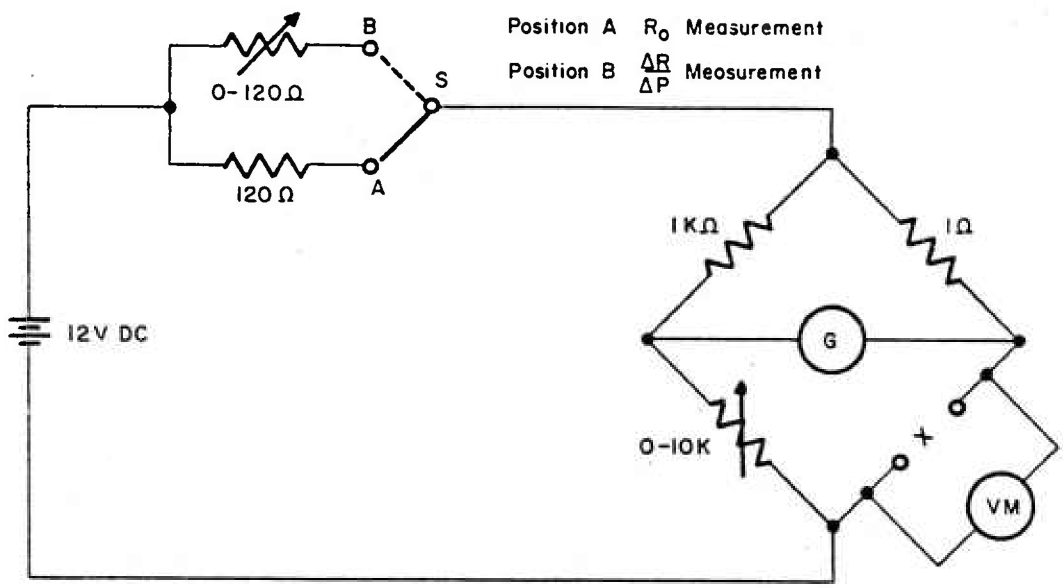

Figure 2-1 Circuit for R_o and $\Delta R/\Delta P$ Measurements

The method of testing was manual and relatively slow, but the accuracy proved to be very good. It was used in nondestructively examining a lot of T77 detonators. [4] Results gave predictable current for firing on each individual detonator that was accurate within about 1%.

Based upon nondestructive tests, predictions were made on an individual detonator basis as to whether a particular detonator would fire when exposed to a current of 74 mA for 10 seconds. Of 30 predictions made in this fashion, results of the predictions were 100% correct.

This work was expanded and summarized for portions of the space program. [5]

More recently, other researchers have looked into the meanings of various faults by intentionally creating problems within electroexplosive devices. [6] Subsequent electrothermal studies were made to determine to what degree construction and material faults were detectable.

A different ignition mix from the normal was loaded into 20 EEDs. All proved to deviate from the mean, and 4 of the 10 were off more than the 3 sigma limits set by a lot evaluation of the normal device. Solvent contamination was detectable in some cases, not in others. High and low welding currents were used to prepare 10 improperly welded bridgewires. These appeared out of specifications according to thermal testing in six instances, five of which were also out of resistance specifications. One of these, however, appeared normal in resistance but abnormal in thermal testing. Cuts and nicks were made in five bridgewires at 20 to 30% penetration by removal of materials. One was cut through to 70% and the remaining four were flattened. All d.c. resistances were normal. Abnormal thermal tests were experienced on the wire cut through 70% and on bridgewires that were flattened for 80% of their length. Loading pressure was incrementally increased as thermograms were made on 10 items. All 10 items showed abnormal thermograms at 2000 and 5000 psi loading pressures. At 10,000 psi, 9 of the 10 showed abnormal thermograms; at 15,000, 4 of 20 and at 18,000 and 20,000 psi all were normal.

This short historical summary, admittedly incomplete, indicates the state of the art when the work reported here began. No one, to the best of our knowledge, has done large-lot testing on electroexplosive devices with the expressed purpose of relating electrothermal tests to different types of electric detonators.

Instruments were available to test electric detonators at the onset of this program.* The decision was made to purchase the instrument rather than to build one.

2.2 THEORY

The theory of electrothermal testing is a simple one. Success of the test depends upon sensing the change in resistance of the wire bridge element. The resistance change is the result of heat input that is supplied electrically and also the result of heat losses that occur because of heat conduction or convection from the bridge wire. Hence, the bridge wire or convection from the bridge wire surrounding the primary charge, has a large effect. Rosenthal [7] has derived an equation representing the electrothermal parameters of a bridgewire system as follows:

$$C_p \frac{d\theta}{dt} + \gamma\,\theta = P(t) = I^2 R_o (1 + \alpha\,\theta) \tag{1}$$

C_p - heat capacity of the bridgewire-explosive system
θ - temperature rise
t - time
γ - heat loss
I - excitation current
R_o - initial resistance
α - temperature coefficient of resistance of the bridgewire

Application of this equation is accomplished via a thermogram represented by Figure 2-2. This thermogram occurs as the result of the application of a constant current pulse. Certain measurements are indicated on this figure that are pertinent to calculation of the electrothermal parameters. From these measurements, the following parameters are derived:

*As, for example, from Pasadena Scientific Industries, 495 South Arroyo Parkway, Pasadena, CA 91105.

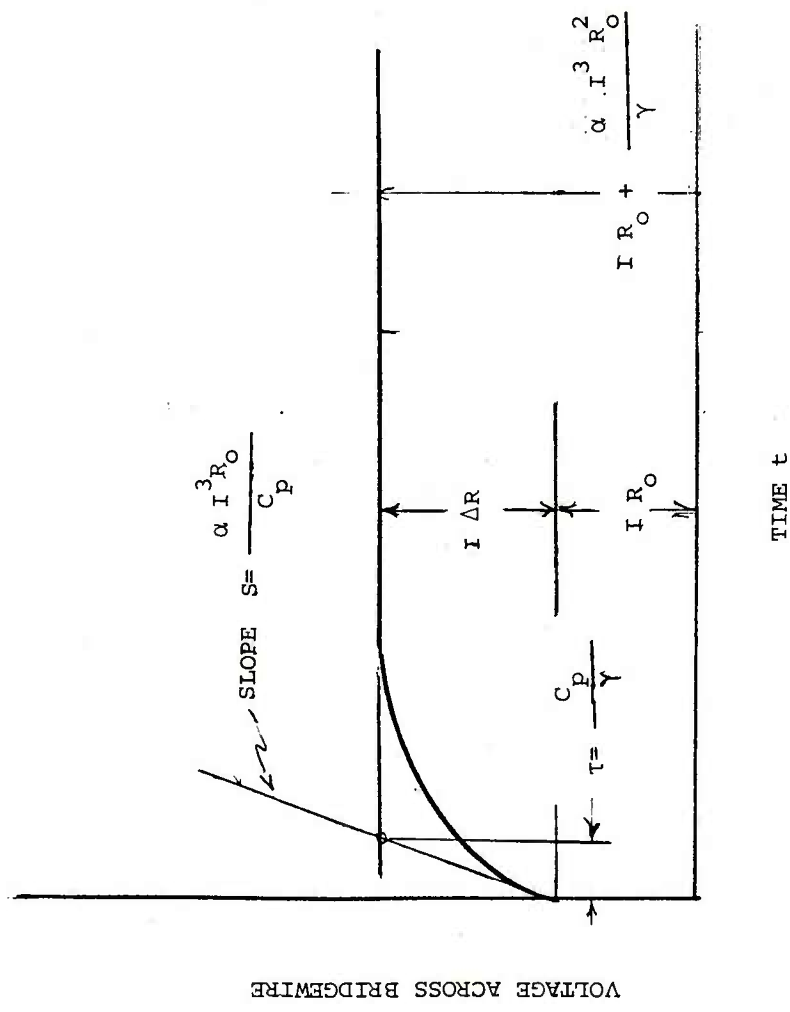

Figure 2-2 Voltage-Time Relationships on a Pulsed Bridge Wire

FORM 207-10M-4-74-CP

Temperature rise ($\bar{\theta}$) is computed from

$$\theta = \frac{\Delta V_m}{I R_o \alpha} \tag{2}$$

Thermal conductance (γ) from

$$\gamma = \frac{\alpha R_o^2 \; I^3}{\Delta V_m} \tag{3}$$

Thermal capacitance (C_p) from

$$C_p = \frac{\alpha \; R_o^2 \; I^3}{S} \tag{4}$$

and Thermal time constant (τ) from

$$\tau = \frac{t}{0.69} \tag{5}$$

One major purpose of the work described in this report relates these measured parameters to the quality of electroexplosive devices, thereby permitting their nondestructive evaluation.

3. TEST METHODS AND EQUIPMENT

3.1 GENERAL

Thermal transient testing of electroexplosive devices is a fairly straightforward process. It requires a bridge circuit which can null out the initial resistance of the explosive device, a constant-current pulse generator, and a detector to monitor bridge imbalance in response to the device's resistance change. In the past it was common practice to monitor bridge imbalance with an oscilloscope and to characterize the wave shape by measuring the curve on an oscillograph. If, however, you wish to test a large number of devices rapidly and obtain the results immediately then this method will not serve. We have attempted, therefore, to develop an improved method of acquiring and analyzing thermal transient data with a view to eventual refinement into a fully automated system. The general system block diagram is shown in Figure 3-1.

3.2 TEST EQUIPMENT

3.2.1 Thermal Transient Test Set

The thermal transient tester is manufactured by Pasadena Scientific Instruments and the unit we are using is a Model 605B. The test set contains a bridge circuit which is adjusted to null out the initial resistance of the device being tested. At null, this initial resistance can be read from a pair of dials on the test set. Current for testing and nulling is provided by an adjustable constant-current pulse generator. Pulse amplitude can be varied from 10 mA to 3000 mA and pulse duration from 15 ms to 70 ms. Nulling is done with a repetitive 10 mA pulse having the same duration as the test pulse. Output from the test set is the imbalance voltage across the resistance bridge. This is proportional to the voltage change across the test device. The tester also provides a trigger pulse which leads the test pulse by about 5 ms.

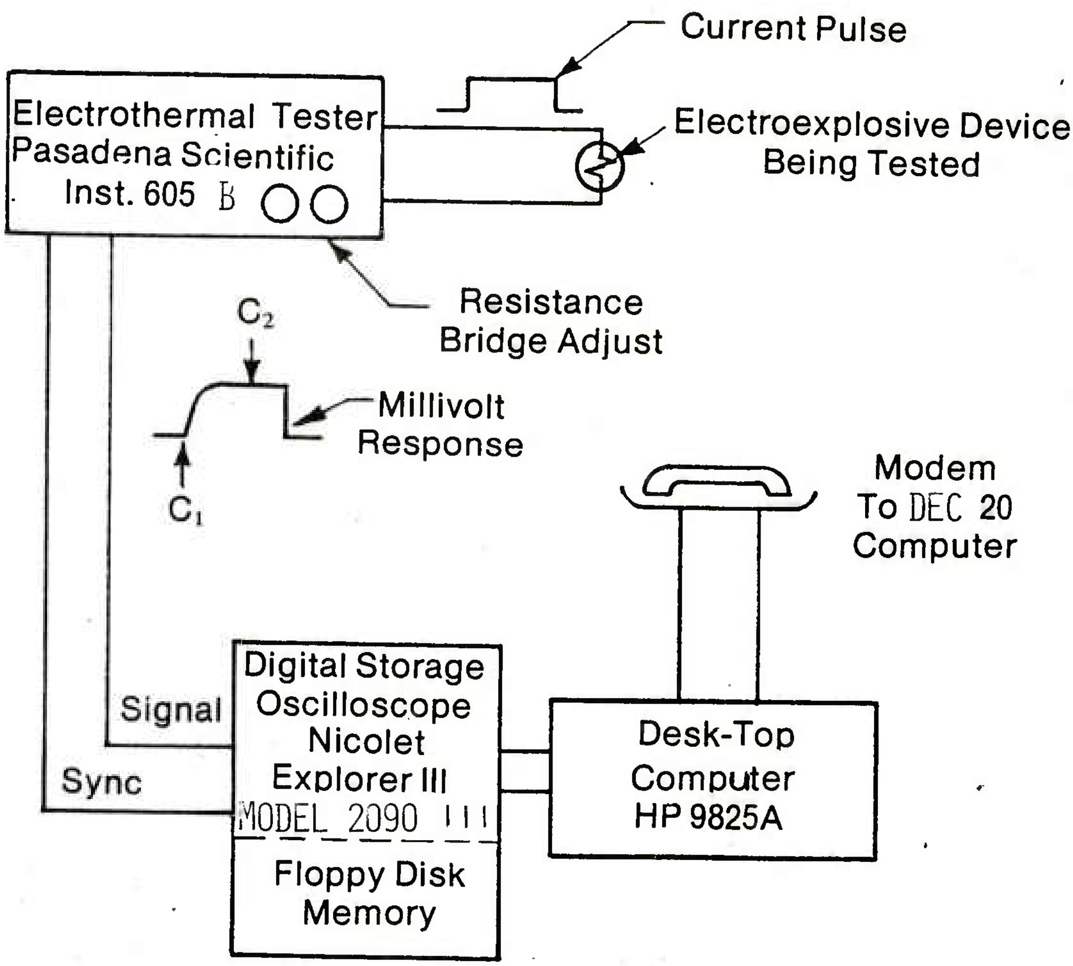

Figure 3-1 Block Diagram of System Used for Electrothermal Data Collection

3.2.2 Digital Oscilloscope With Recorder

The oscilloscope used to monitor the output of the test set is a Nicolet Explorer III Model 2090-III with a Model 206 front end plug-in. (Nicolet Instrument Corporation) This oscilloscope is capable of digitizing 4096 data points at rates up to 500 ns per point. On its most sensitive range the oscilloscope will digitize in steps of 50 microvolts. A mini floppy disk recorder allows the digitized waveforms to be saved either at full resolution or at reduced resolution with increased disk capacity. Finally, the scope is equipped with a Model NIC-2081 interface (IEEE Standard 488-1975) which permits it to be used in conjunction with compatible instrumentation.

3.2.3 Control Computer

The control computer is an HP 9825A Desktop Computer manufactured by Hewlett-Packard Company. This computer interfaces the Nicolet oscilloscope via the HP 98034A Interface Card (IEEE Standard 488-1979) and can control the oscilloscope and acquire data from the scope's memory. The 9825A can record data on magnetic tape and it can also communicate with our mainframe computer, a Digital Equipment Corporation DEC-20, by means of an HP 98063A Serial I/O Interface (RS 232C).

3.3 TEST METHODS

3.3.1 General

The method used to conduct the thermal transient tests evolved considerably during the course of this program. As we acquired sufficient data on a given test item we were able to better define its limits of response and could, therefore, focus our testing within these limits. Conversely, when testing less responsive devices, it was necessary to treat the data somewhat differently. Also, as testing progressed we became more familiar with capabilities and limitations of our instrumentation and were able to improve our procedures accordingly.

3.3.2 Thermal Response Curve Analysis

Once certain characteristics of the thermal transient response curve have been determined it is possible to define the electrothermal properties of the test item. The characteristics of interest are the maximum voltage, the initial slope, and thermal time constant. To define these parameters requires the definition of only two points on the curve: the start of the curve, V_o, and the maximum, V_{max}.

Figure 3-2 shows a hypothetical digitized waveform. There is usually a spike, as shown, at the beginning of the applied pulse. This presents some difficulty in determining the location of V_o. We have tried to insure that V_o is the start of the thermal portion of the curve and not part of the switching transient. Initially, we selected the first data point after the minimum as V_o and this seemed to work fairly well as long as the items being tested had a large thermal reponse. All of the SCD 10383 fuses were tested with V_o set at this point. V_{max} does not usually present any difficulties.

In its first version the curve analysis program requires that operator specify the loctions of V_o and V_{max}. This was done by moving the scope cursor to the desired point and then resetting the scope. All of the SCD 10383 tests and the Series I detonator tests were conducted using this method. The test method and the analysis program were then changed to further automate the test procedure. In the second method the first 1000 data points are read into the computer. Experience has shown that this is sufficient for the curve to have reached equilibrium. The computer then determines the minimum and maximum values which it has organized. The maximum value is V_{max}, the minimum value checked against several subsequent values to determine if it is the beginning of the uniform portion of the curve. If it is not, V_{min} is incremented to V_{min} + 1 and the check repeated. When a V_{min} + n is reached which satisfies the requirements that point is designated as V_o.

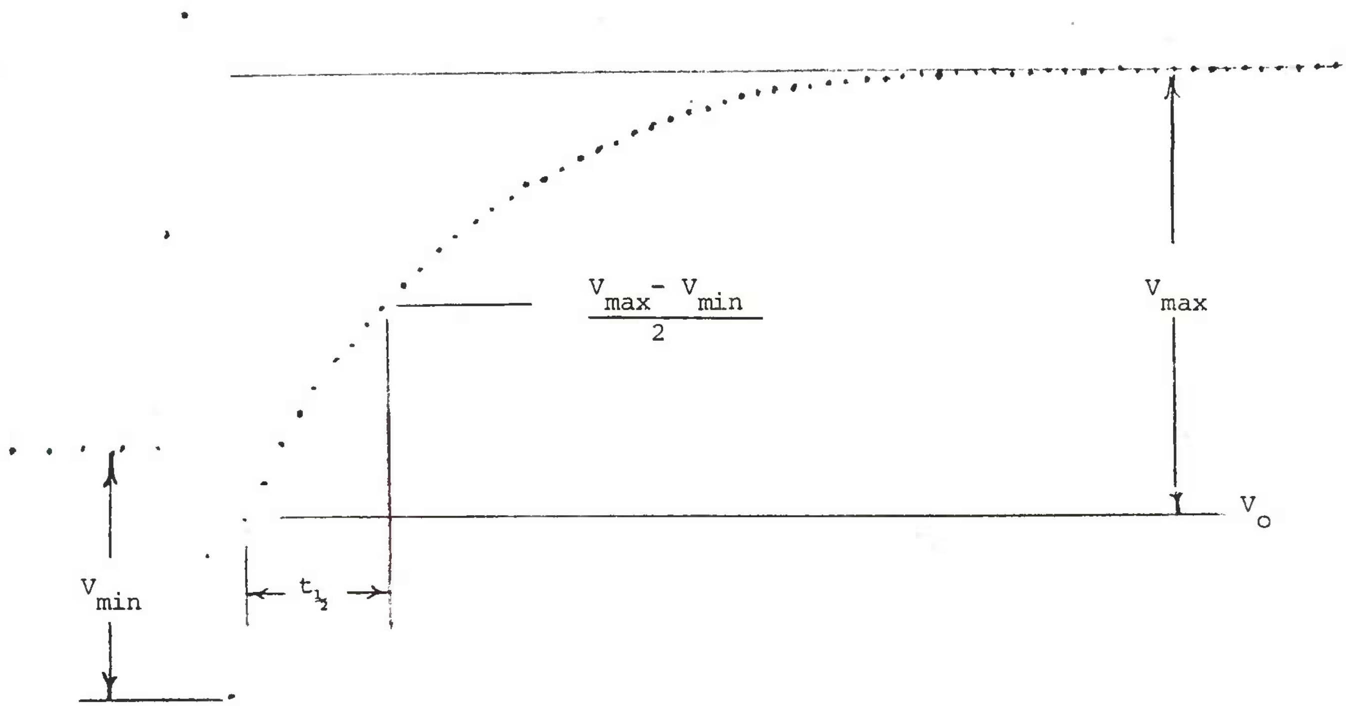

Figure 3-2 Digital Thermal Transient Response Curve - Typical

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With V_o and V_{max} defined, we start at V_o and check the voltage at each subsequent point V_n until we find $V_n = (V_{max} - V_o)/2$. If $V_n = (V_{max}-V_o)/2$ then the time for the voltage to reach one half of V_{max} is simply n multiplied by the time per data point. This is $T_{1/2}$ usually, $V_n = (V_{max} - V_o)/2$ and in this case a straight line interpolation is made between V_n and V_{n-1} to determine $T_{1/2}$ the thermal time constant is given by $T_{1/2}$ ln 2.

The slope of the curve is measured starting from V_o and usually taken over the first 100 microseconds. When working with the well-behaved SCD 10383's, we simply take the voltage difference between V_o and V_{20} (this assumes a data acquisition rate of 5 microseconds per point) and divide by 100 microseconds. This, of course, is not exact, but is sufficiently accurate for comparative measurements. When testing the detonators, however, the poor signal to noise ratio makes this method unacceptable. Therefore, linear regression was applied to the first 20 data points to determine the slope.

3.3.3 Thermal Transient Test SCD 10383

Preliminary testing indicated that a 20 mA pulse would produce a good response curve and, therefore, the first test segment was conducted at this level using a pulse length of 16 ms. Data were taken at a rate of 50 microseconds/point and the initial slope was evaluated over the first 500 microseconds. This first sequence comprised test numbers 1000 through 1100.

At the conclusion of the first sequence we decided that the data acquisition rate should be increased to improve resolution. This allowed us to observe the beginning of the pulse in greater detail and better define the starting portion of the thermal rise. Also, we were able to reduce the time period over which the initial slope was evaluated.

The 25 mA tests (Nos. 2002 through 3100) and the 30 mA test (Nos. 3001 through 3100) were conducted using a 16 ms pulse with a data acquisition rate of 5 microseconds/point and an initial slope of 50 microseconds.

3.4 ENERGY TO BURN OUT BRIDGEWIRE

Using the SCD 10383 devices, tests were conducted to see if a correlation could be established between thermal transient response and energy required to burn out the bridgewire. The Pasadena thermal transient test set was used to measure initial resistance and to supply the current pulse for these tests but separate circuitry was employed to monitor bridgewire current and voltage. A low resistance was inserted in series with the test device and the voltage across it was used to monitor current. At the same time the voltage across the test device was determined so that power could be calculated.

Energy delivered to the bridgewire was found by integrating the power from the beginning of the pulse to bridgewire failure. A trapezoidal approximation was used employing the sampling rate, 5 microseconds, as the interval.

3.5 THERMAL TRANSIENT TESTS PA-506 AND M-100 DETONATORS

Thermal transient tests on the PA-506 and M-100 detonators were all conducted using 60 mA pulses 16 ms long. The data requisition rate was 5 microseconds/point. Thermal response of the detonators is quite low compared to the SCD 10383's and, consequently, the signal to noise ratio is much poorer. To obtain a meaningful measure of the initial slope it was necessary to increase the evaluation time to 100 microseconds. Tests performed this way constitute Series I which includes the following:

PA-506	Nos. 8151 through 8204*
	Nos. 8555 through 8640
M-100 Lot 098	Nos. 8305 through 8354*
M-100 Lot 069	Nos. 8361 through 8410*

At the conclusion of the Series I test the data were evaluated and we decided that the initial slope could be defined better by performing a linear regression over the 20 points which make up the first 100 microseconds. All

*Most of these items were expended in the second set of Bruceton tests.

of the Series II tests were done in this manner. Series II consists of only one test: PA-506, Nos. 8591 through 8640.

Series III tests are the same as Series II except that the data acquisition has been further automated. In Series III the computer program is able to determine the beginning and the maximum of the response curve instead of having them entered by the operator. Series III comprises the following:

PA-506	Nos. 8641 through 8690 Nos. 8891 through 8940
M-100 Lot 098	Nos. 8891 through 8940 Nos. 8841 through 8890
M-100 Lot 069	Nos. 8741 through 8840

4. FUSE TESTING PROGRAM

4.1 GENERAL

The fuse being tested is actually a system component of a current weapon system. It is a fully enclosed element with the appearance of a detonator. The fuse testing program included an evaluation of the electrothermal tester. The complete program for the fuse and tester is contained in Appendix A. To keep them in order, each of the 1000 fuses was placed in a coin envelope and given a number. Items tested nondestructively could be placed in the envelope and retrieved for further examination if necessary.

4.2 TESTING OF FUSES

4.2.1 Preliminary Tests

Preliminary evaluation included determining what current levels may be used to test the fuses without permanent effect on performance, checking adherence to equations and generally examining fuses.

This fuse was found to withstand about 30 mA without adverse effect. At 35 mA, one fuse opened on the 7th pulse.

It was found, by repeated exposures on the same fuse at increasing currents that the thermal time constant (τ) increased, the heat loss factor (γ) decreased and that the system heat capacitance (Cp) maximized and then decreased. (See Table 4-1)

The supposition that γ and Cp are constants in this particular instance is apparently unfounded unless there are serious changes in the fuse bridge wire system as pulses are repeated.

The apparent lack of conformance of observed data to the equations is really of little consequence to the ultimate value of the test. Generally, nondestructive testing will be done utilizing only one value of test current,

Table 4-1. Analysis of Thermal Parameters as a Function of Current (Fuse No. 998)*

Current (mA)	Initial Resistance (R_o)	Maximum Voltage (V_m)	Thermal Time Constant (τ)	Slope (S)	Temperature Rise (θ)	Heat Capacity (C_p)
20	7.403	18.4	256	48	36.6 81.01	0.92
25	7.412	15.0	241	48	23.8 195.0	0.60
30	7.450	91.2	360	192	120.0 55.8	3.04
30	7.450	90.4	360	192	120.0 55.8	3.04
35	7.450	23.7	567	320	267.0 34.1	6.77
35	7.450	23.4	558	320	263.0 34.6	6.67

* These calculations were performed with a calculator.

thereby narrowing any effects introduced by the apparent theoretical anomolies observed.

Repeated tests for initial resistance (R_o) using clip leads to connect the fuse to the ND tester, show that firm connection to the item under test is necessary. We finally used a zero-insertion-force IC socket to establish good connections and continued using this method of connection throughout the remaining tests on fuses.

4.2.2 Fuse Testing for the Record

Appendix B gives detailed results on electrothermal testing of fuses. Histograms were made of each variable as shown in Appendix C (Phases 1.1 and 1.2 of Test Plan). For 25 mA tests, R_o was well behaved and all values fell within 3 standard deviations of the mean. Maximum voltage values (V_m) revealed that 4 of maximum temperature values were more than 3 σ greater than the mean. One thermal time constant (τ) value was more than 3 σ greater than the mean. Six values of 300 of the initial slope (S) values were more than 3σ greater than the mean. Two temperature values were 3σ greater than the mean. Seven heat loss values were more than 3σ greater than the mean.

If all of those fuses greater than 3σ from the mean were discarded, then less than 10% of the samples would have been eliminated. Even if the "bad" items were actually usable, this would be of little consequence compared to an accident or a dud.

The 20 mA test revealed very little about the fuses. Only about 4 of 100 fuses tested were outside the 3 σ limits on all variables. The 20 mA test may be well into noise level thereby limiting the ability to discern problems by electrothermal testing.

Tests were also made at 30 mA. While some additional signal over noise was noted, it is believed that 30 mA is too close to the excitation level where some items would be permanently changed by the test current.

These tests completed our examination of the items. Remaining to be done, and most difficult to deduce is the meaning of these tests with respect to fuse quality.

4.2.3 Destructive Testing

Samples from each of the three groups of devices that were tested nondesructively were exposed to current levels almost certain to open the fuse, nominally 40 mA. Two primary parameters were measured during current application, both relating to fuse opening. These were energy to open and time to open.

To test the linear correlation of NDT-measured and computed variables among themselves and with the opening times and opening currents, a computer program was applied to determine correlation coefficients. The data for three NDT test currents and correlation matrices for these three conditions are given in Appendix D.

The correlation matrices at the end of Appendix D are an extremely powerful means of comparing the destructive parameters (energy-to-break and time-to-break) with the nondestructive parameters determined earlier. The coefficients were examined and those showing absolute values of 0.4 or greater were recorded in Table 4-2. This table shows parameters 11 (energy to open) and 12 (time to open) in terms of R_o (initial resistance), V_m (max voltage), τ (thermal time constant), S (initial slope) and θ (temperature) for the three groups of data representing NDT currents of 20, 25 and 30 mA.

A correlation coefficient of 1 is perfect, 0 indicates no correlation and -1 is perfect, but negative. All values in this table are negative, meaning that time and energy to break decrease as the other measured values increase.

Table 4-2. Comparison of Correlation Coefficients

Variable	Initial Resistance (R_o)	Maximum Voltage (V_m)	Thermal Time Constant (τ)	Slope (S)	Temperature Rise (θ)	Test Current (mA)
11 - Energy to open	-0.6566	-0.5892	-0.03	-0.6616	-0.4371	20
12 - Time to open	-0.6945	-0.5799	-0.05	-0.6347	-0.4768	
11 - Energy to open	-0.4887	-0.5112	-0.09	-0.5505	-0.4747	25
12 - Time to open	-0.4971	-0.5056	-0.010	-0.5441	-0.4648	
11 - Energy to open	-0.5623	-0.4568	-0.4020	-0.4062	-0.4084	30
12 - Time to open	-0.5411	-0.4374	-0.4075	-0.4187	-0.4187	

Some tentative conclusions concerning fuse performance can be derived from these correlated data:

R_o - initial resistance is a fair measure of break time and energy to break.

V_m - max. voltage - is also a good measure of these parameters.

τ - thermal time constant - is poor for test currents of 20 and 25 mA but a marked improvement shows at 30 mA.

S - the initial slope - correlation is good at low test currents and degrades for higher test currents.

One problem with the analysis is that linear correlation was used throughout. A few non linear methods were tried that indicate better fit to a power curve, i.e. a log-log plot. Unfortunately, time prohibited the treatment of these data in log-log terms.

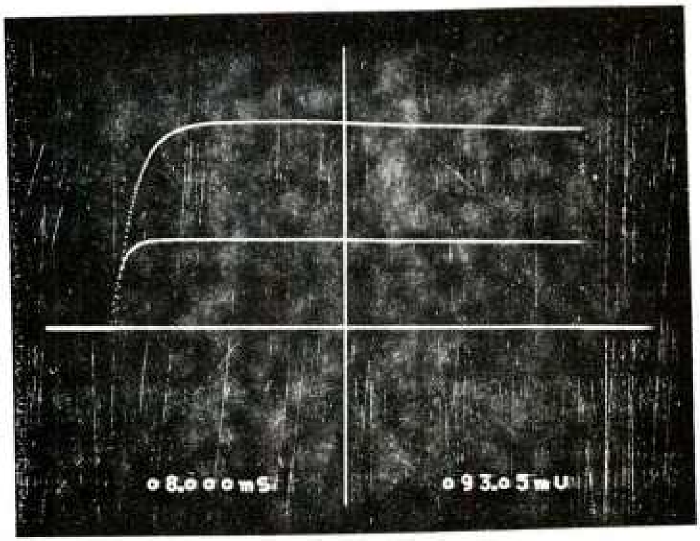
4.2.4 Extraordinary Waveforms

Allowance was made in the test plan for any waveforms that were different in basic shape. Items showing such waveforms were to be culled and subsequently examined with the purpose of determining the reasons for departure from the norm.

Figure 4-1 illustrates a normal response as displayed on an oscilloscope and an extremely high response. After removing the fuse case, the fuse giving a high response, looks like the one in Figure 4-2. Not all normal fuses look as good as the one giving a normal response and shown in Figure 4-3. Some devices show extremely low responses (Figure 4-4). These look like the photomicrograph of Figure 4-5 when dissected.

The distance from the plane of the header face to the wire play an important role in determining whether the response is high or low.

One of the most important findings of the entire fuse testing program is demonstrated in the oscillogram of Figure 4-6. Note that the response of this fuse is not high or low but of an entirely different shape. Remember, at the time this oscillogram was taken there was no way of viewing the bridgewire itself. Removal of the outer case revealed the bridgewire shown in the photomicrograph of Figure 4-7. Expulsion during welding caused several metal



= High Extreme Response
Test 2099

= Normal Response
Test 2134

Figure 4-1 Thermogram of High-Response Fuse With Normal-Response Fuse

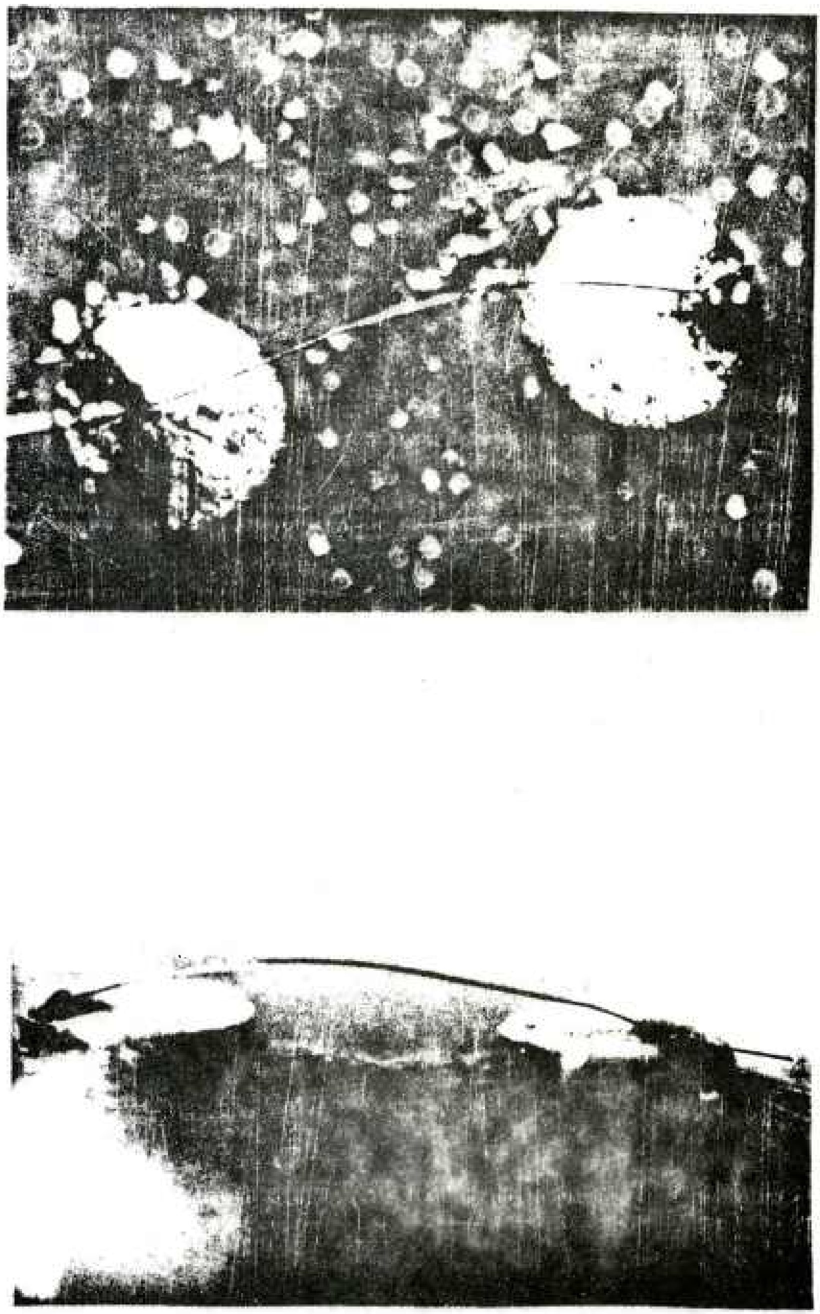


Figure 4-2 Plan and Elevation Views of High-Response Fuse

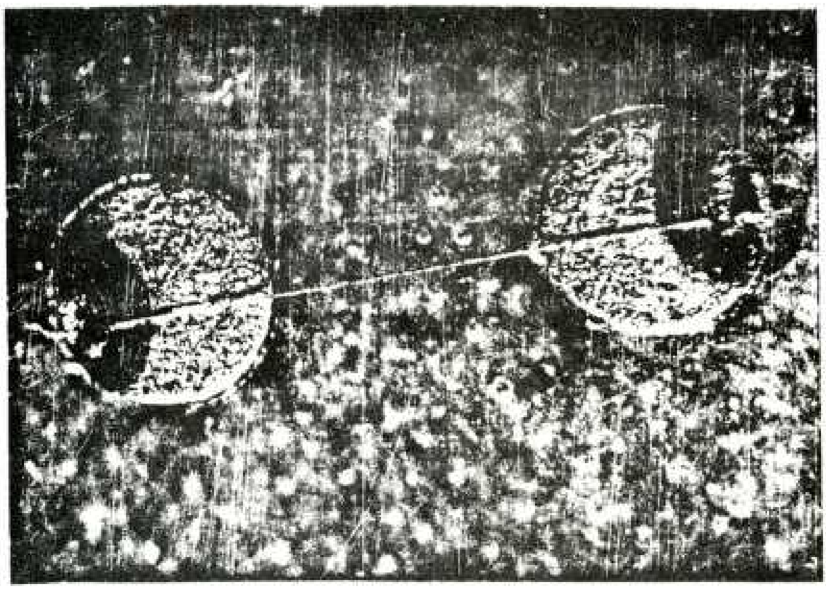


Figure 4-3 Plan View of Normal Fuse

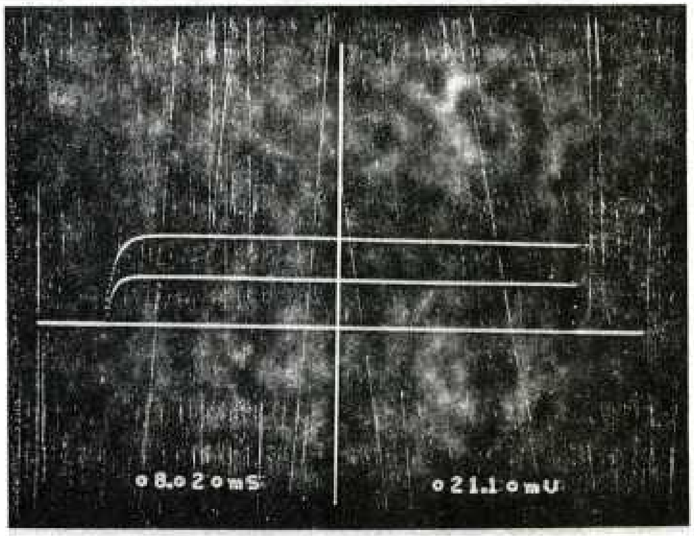


Figure 4-4 Thermogram of Extreme Low Response Fuse

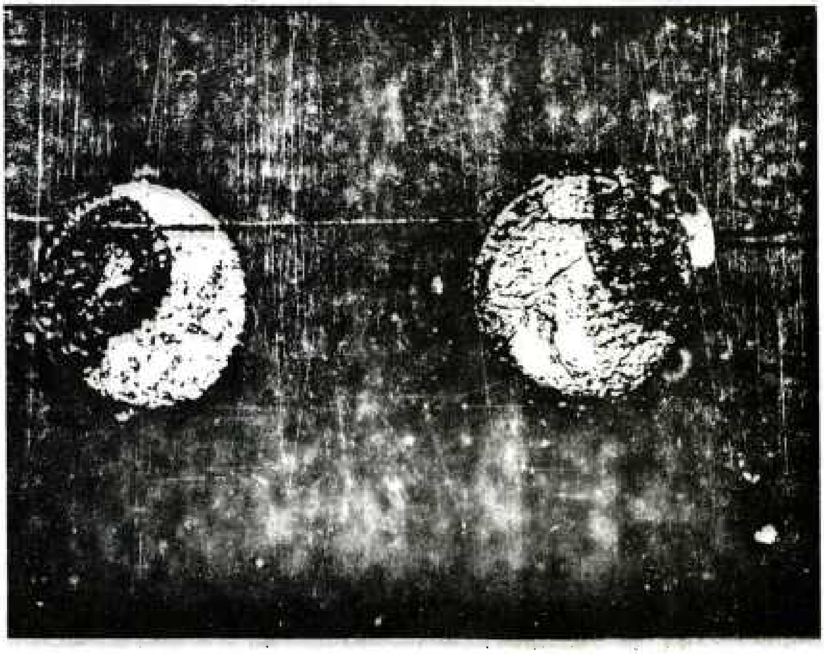


Figure 4-5 Photomicrograph of Extreme Low response Fuse

globules to form on the bridgewire. These unbalanced the thermal state of the system enough to make its thermogram stand out during electrothermal testing. In use, this condition could result in high wire stresses during vibration with the likelihood of the wire failing during vibration.

This kind of finding could reduce in-service failures of fuse components and add materially to the quality of weapon components. One such finding in a lot of EEDs designated for missile service and otherwise tested for quality assurance is well worth the testing effort. The device is bent to failure, but this NDT would have shown the device to be defective.

This one fuse response and subsequent dissection demonstrate effectively the value of the ND test in discovery of faulty bridge wire systems.

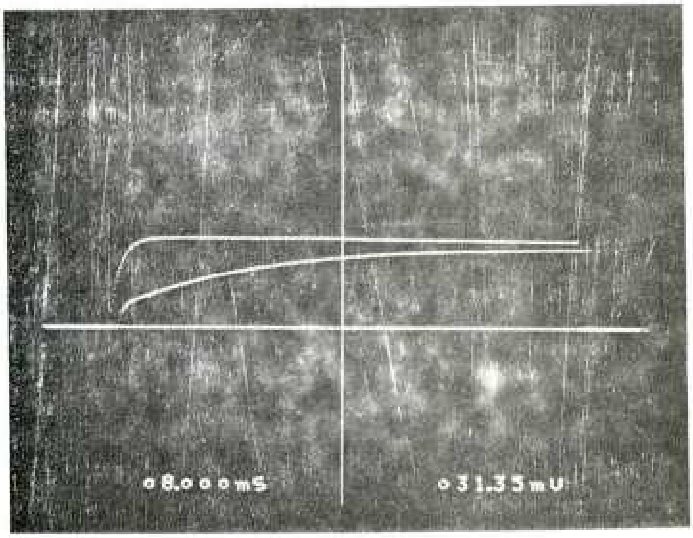


Figure 4-6 Thermogram of Badly Shaped Response vs Normal Response

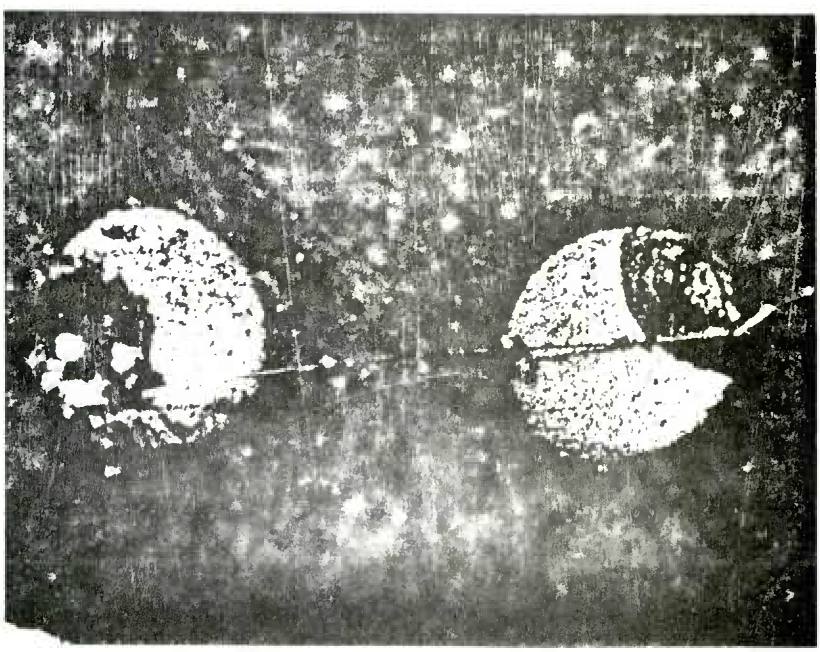


Figure 4-7 Photomicrograph of Thermal Reject

5. DETONATOR TEST PROGRAM

5.1 GENERAL

Two detonator types were assigned by the Contracting Officer to be tested during this program, the M100 and the PA 506. A test plan was submitted and approved. This plan is contained in Appendix E.

These are both microdetonators, containing only several milligrams of explosive. The bridgewire material used on both detonators is an alloy (known as moleculoy[R]*) stated to have a thermal coefficient of resistance (α) of ± 5 parts per million. This value of α is under question due to (1) actual measurement made at the report originators facility and (2) measurement made by L. Rosenthal and reported in a private communication (.0000705).

Furthermore, if α is as small as reported, then it would be extremely difficult to obtain any thermal responses.

5.2 PRELIMINARY EXAMINATION - PA506 DETONATOR

Samples of the PA506 detonator under study were exposed to pulse currents from the Pasadena instrument in progressively increasing steps until firing occurred (Figure 5-1). Thermal signals were clearly evident from the thermograms. At this time, it was deemed possible to measure thermal parameters by actual experiment despite the low value of α anticipated from data.

Currents of 60, 70 and 80 mA gave clear, rising thermograms and a current of 90 mA fired the detonator in about 5 milliseconds.

5.3 EXECUTION OF TEST PLAN

The test plan of Appendix E was begun as indicated. Findings of Bruceton tests on untested items and those tested at a current representing a very low firing probability (60 mA) were that there was no significant difference as a result of the ND testing.

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*Moleculoy is a registered trade name of Molec-Wire Corporation, a subsidiary of Superior Tube Co., Norristown, Pa.

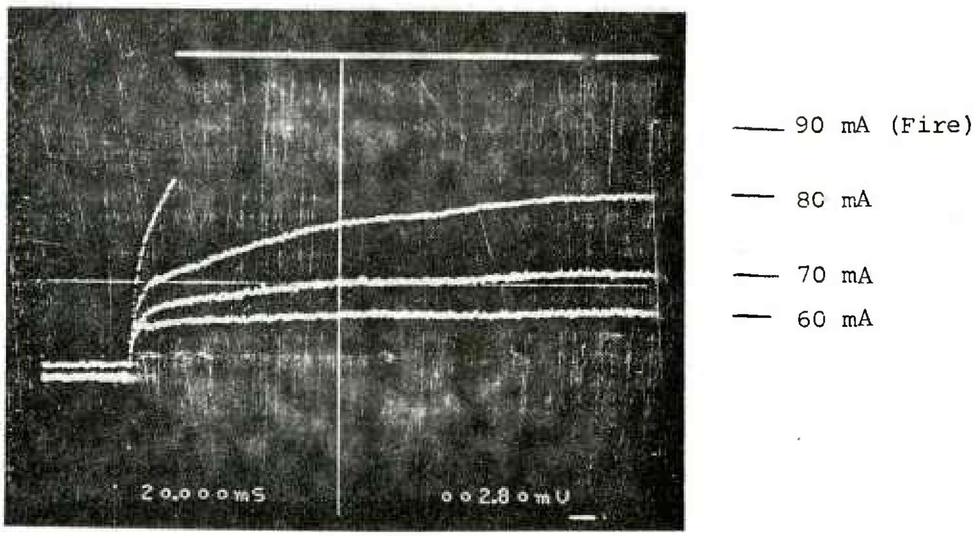

Figure 5-1 Effect of Increasing Current on Electrothermogram PA 506 Detonator

It was therefore decided to proceed, running all nondestructive tests at a current of 60 mA. This was done as indicated in Table 5-1.

The nondestructive test parameters for the PA506 detonators are tabulated in Appendix F. Those from the two lots of M100 detonators are contained in Appendix G.

The PA506 lot of detonators represent production items that have been thoroughly checked for quality. One lot of M100 detonators (Lot 098) has passed the quality test. The second lot (Lot 069) is a rejected lot. Reasons for rejection were quoted to be a "marriage failure.*" Six Bruceton Tests were run, one for each detonator lot, before and after exposure to NDT pulses to select current excitation levels and then to determine if this level caused significant changes in detonator sensitivity.

The results are tabulated in Appendix H. One can see by inspection that 60 mA is a reasonable test level for the NDT evaluation. At this current less than one item in a hundred can be expected to fire during the testing process. We used 60 mA for all NDT work despite some minor variations in the probability of firing for the various lots of detonators. Inspection of the means before and after exposure shows that there is no significant difference in the means. There appears to be some kind of stabilization in the detonators as a result of the 60 mA prepulse. Table 5-2 illustrates and summarizes data taken from Appendix H.

While the means are not significantly different, there is obviously some "pull in" in the spread as a result of prepulsing. In this sense, prepulsing is not an adverse effect but rather a benefit. More effort is warranted in this area of investigation. Prepulsing may actually benefit quality.

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*A marriage failure results when the detonator fails to initiate a booster or lead that is the next element in the explosive train.

Table 5-1. Summary of Detonator Tests

Experiment	Number of Items Tested PA506	M-100-098	M100-069
Bruceton	40	40	40
Thermal NDT	250	150	150
80/130 mA Pulse	100	100	100
Bruceton	40	40	40
Repetitive	50	---	---
Repetitive (65 mA)	50	---	---

Table 5-2. Summary of Mean and Standard Deviation on PA506 and M100 Detonators

Detonator Lot		Statistics Before Prepulse		Statistics After 60 mA Prepulse	
		Mean (Amps)	Std. Dev. (Log Amps)	Mean (Amps)	Std. Dev. (Log Amps)
M100	190-098	0.097	0.08256	0.097	0.03233
M100	190-069	0.099	0.04729	0.102	0.02963
PA506	-	0.102	0.05278	0.101	0.03067

6. INTERPRETATION OF DETONATOR TEST RESULTS

6.1 NDT - SENSITIVITY RELATIONSHIPS

An experiment was conducted to demonstrate the ability to use NDT measurements to sort extremely sensitive devices and extremely insensitive devices from a lot of detonators. To do this, a lot of PA506 detonators and two lots of M100 detonators (lots 069 and 098) were given NDT to measure and record all thermal parameters (Appendix G contains NDT data) All of these detonators were then subjected to the 10% firing current and then the survivors from the 10% current were subjected to the 90% firing current. The NDT data on those items affected by these tests were then scrutenized for information leading to the cause of their behavior.

Once the items were separated by testing, their NDT characteristics were tabulated (Table 6-1). These data were then analyzed by finding their deviation from the mean for each of the nondestructive measurements. A plot was made for each of the ND parameters for the 10 items found either to fire at the 10% point or not to fire at the 90% point (Figure 6-1).

There is a definite trend in most of the parameters:

R_o is clearly an important sensitivity indicator.
V_m is also indicative of firing sensitivity.
TTC is mixed as an indicator of sensitivity but in a small area of overlap.
S is also mixed slightly.
is mixed but somewhat definitive.
and Cp are both mixed without clear predictor trend.
R is clearly indicative and unmixed.

There is definite advantage to making six of the nine measurements. The only ones of questionable value are gamma and Cp. Remember, we are faced with a very small value of thermal coefficient of resistance (α) in both of these detonators and are therefore less likely to be able to discriminate their thermal characteristics than we would be were the α values in the .0001 range instead of the .00001.

Table 6-1 Computation of NDT Parameters for 10/90, Fire/No Fire Detonators (PA506 and M100)

Det No. PA506 M 100 *	8193	8571	8569	8648	8791*	8809*	8769*	8861*	8716*	8730*
Fire/No	F	F	NF	NF	NF	F	F	F	NF	NF
MEASURE										
R_o	5.26	5.51	3.86	3.37	3.41	5.42	5.91	4.81	3.19	3.51
$N\sigma$	1.17	1.60	-1.21	-1.92	-2.10	1.12	1.91	0.49	-1.99	-1.50
V_m	4.58	3.88	2.01	0.74	0.87	3.70	5.52	1.56	1.52	1.08
$N\sigma$	0.84	0.30	-1.16	-1.49	-0.75	1.57	2.84	0.17	0.10	-0.66
TTC	14	17	12	176	215	721	907	323	342	69
$N\sigma$	-0.27	-0.22	-0.31	-0.69	-0.72	1.85	2.80	0.12	0.23	-1.32
S	18.5	16	10.5	1.92	1.80	4.48	4.62	1.75	2.05	1.26
$N\sigma$	0.34	-0.11	-2.99	-0.73	-0.52	2.63	0.86	-0.36	0.11	-1.13
θ	145	117	86.8	36.4	42.6	114	148	53.9	79.3	51.3
$N\sigma$	0.49	-0.23	-1.02	-1.28	-0.49	1.29	2.14	-0.01	1.31	-0.14
G	130	169	160	333	288	171	143	321	1441	246
$N\sigma$	-0.26	0.46	0.30	0.49	-0.28	-1.39	-1.65	-0.08	-1.36	-0.74
C_p	32	40	30	127	139	141	163	285	107	210
$N\sigma$	-0.26	0.79	-0.03	-0.84	-1.08	-1.05	-0.82	0.14	-0.83	-0.27
R	80	60	30	10	10	60	90	30	30	20
$N\sigma$	1.02	0.08	-1.33	-1.77	-0.97	1.49	2.96	0.58	0.58	-0.46

Group Statistics

Population of Items	8193 8571 8569		8648		8791 8809 8769		8861 8716 8730	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev.
R_o	4.53	0.589	4.40	0.536	4.72	0.623	4.49	0.653
V_m	3.50	1.28	1.56	0.549	1.78	1.22	1.46	0.575
TTC	30.3	59.9	283	154	356	196	302	177
S	16.6	5.53	2.48	0.77	2.24	0.852	1.98	0.639
θ	126	38.6	58.6	17.3	62.1	40.2	54.1	19.3
GA	144	54.2	291	86.5	318	106	330	114
C_p	30.4	12.2	186	70.4	242	95.8	260	185
R	58.3	21.3	26.1	9.1	29.7	20.4	24.4	9.59

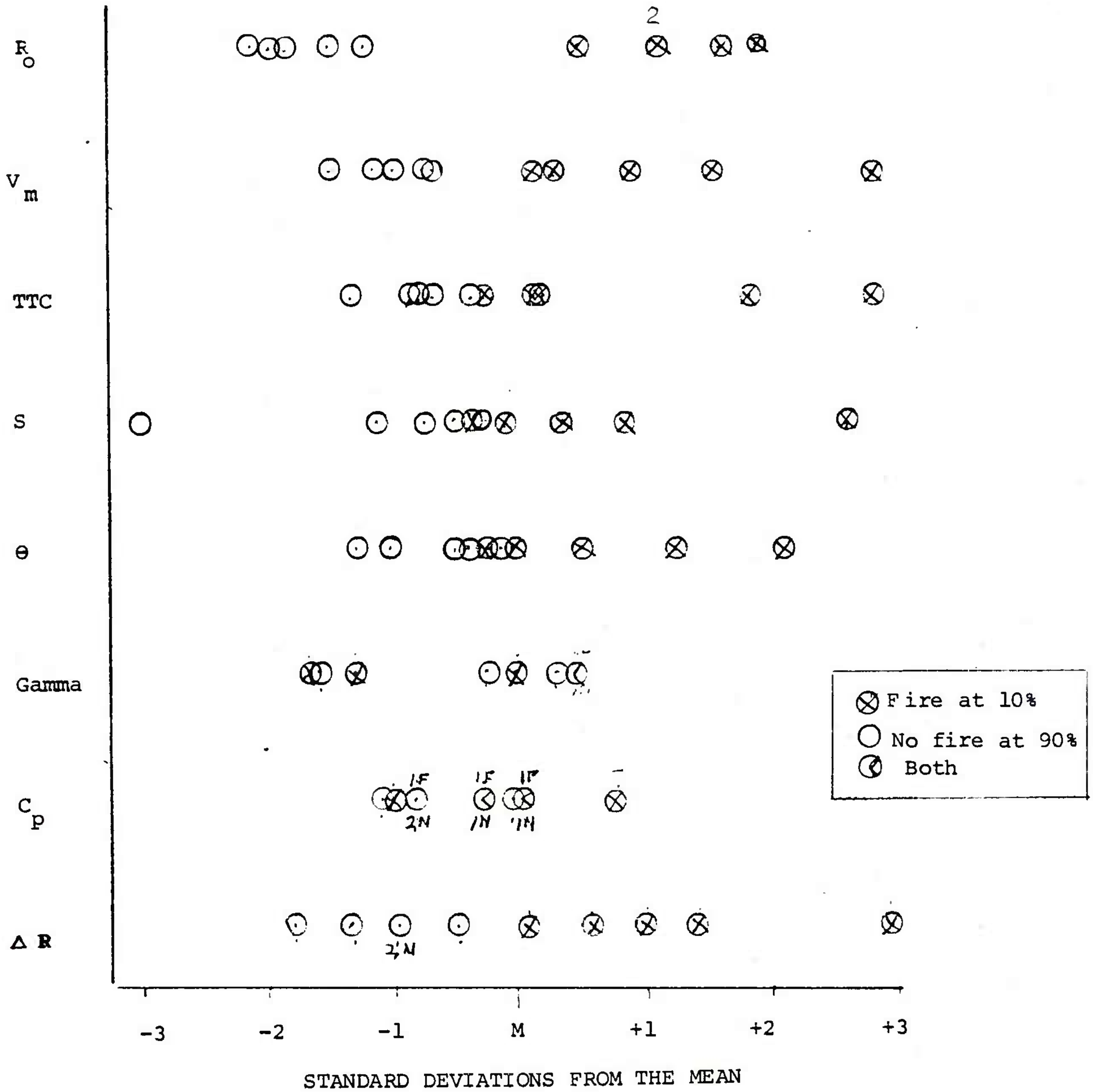


Figure 6-1 Normalized NDT Data

6.2 RATING SYSTEM FOR DETONATOR SENSITIVITY IN TERMS OF NDT PARAMETERS

Individual NDT parameters gave clues to the sensitivity of devices, but with so many parameters available, it looked like all of the available information would be useful in arriving at a "quality number" that would predict the sensitivity of a device or devices with some degree of accuracy.

In searching for such a rating system, the algebraic sum of the deviations for the ten items culled from the entire lot of detonators was determined (Table 6-2). For every detonator that fired at the 10% level, the sum of the deviations was positive. For every detonator that failed to fire at the 90% excitation level, the sum of the deviations was negative.

These data represent only one set of observations. There is no contention at this time that data are of great significance; however, these results deserve more analysis. The measurements are all derived from one exposure of the detonator to a small current pulse. The treatment is quick and effective in yielding the "quality number." The full meaning of this number needs to be explored further.

6.3 MEASUREMENTS OF DETONATORS SHOWING EXTRAORDINARY WAVEFORMS

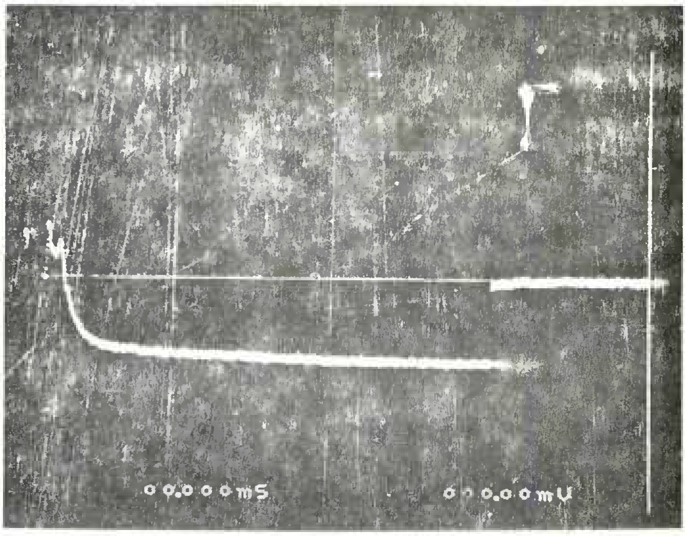
6.3.1 Negative and Noisy Waveform on PA506 Detonator

One PA506 detonator, No. 8909, yielded a negative waveform with a noisy front end. Figure 6-2A shows this waveform as first recorded. The detonator was carefully dissected and the explosive was removed. The photomicrograph of Figure 6-2B shows a flattened section in the bridgewire near the center electrode as well as a small dimple in the weld area. The electrothermogram was repeated (Fig. 6-2C) after the explosive was removed. This time the response was of the same general shape but of much greater magnitude as can be seen in the figure. The higher response could be expected because of the reduced thermal loading resuling from the removal of the explosive.

Table 6-2 Possible Rating System for Detonators Using NDT Derived Data

Item No.	Algebraic Sum of Standard Deviations of All NDT Parameters	Fire at 10% X No Fire at 90% 0
8193	2.07	X
8571	2.67	X
8569	-5.33	0
8648	-8.23	0
8791	-6.91	0
8809	7.51	X
8769	11.04	X
8861	1.05	X
8716	-2.12	0
8730	-6.23	0

C-5174

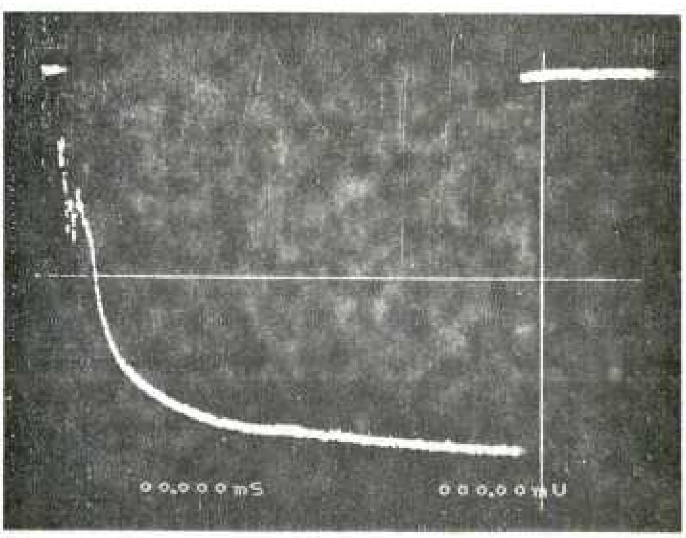


A- INITIAL INSPECTION -PA506- 8909

Waveform deviates from norm. Trend is negative and noise occurs at the beginning of the trace.

B- PHOTOMICROGRAPH

The detonator was sectioned and the explosive carefully removed. Wire is flattened near center conductor. There is a small dimple in the weld near the wire



C- ELECTROTHERMOGRAM

After explosive removal , electrothermogram is repeated. Shape is essentially the same. Amplitude is greater than with explosive present.

Figure 6-2 Anomoly in PA 506 Detonator

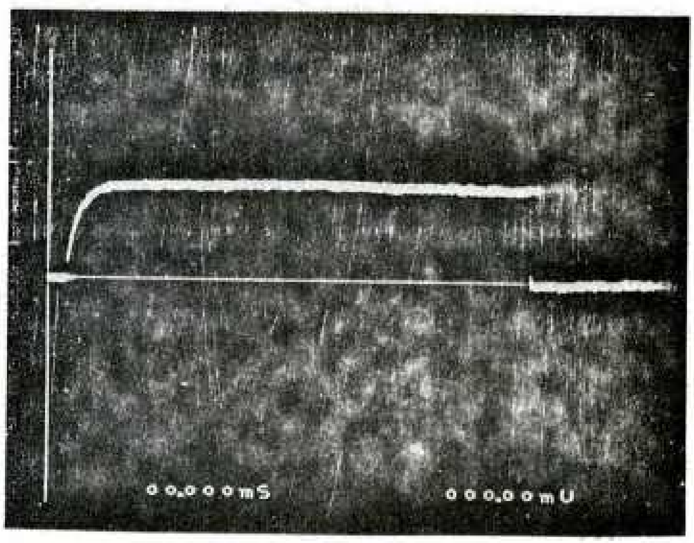
In order to compare the response of the detonator (8909) with an unused header, the header was first photographed (Figure 6-3A) and subsequently exposed to the same pulsed current as the detonator. The response (Figure 6-3B) shows a normal positive going waveform with which the questionable detonator may be compared.

The odd waveshape demonstrated by this detonator is probably indicative of a bad weld. Contact at one end of the bridgewire is probably marginal. It would appear that this detonator may be subject to two potential problems. One would be extreme sensitivity to energy of an electrostatic or electromagnetic nature. The gap or poor connection may be subject to extreme heating under very high voltages such as may be caused by electrostatic or RF induced energy. The second possibility is that continued exposure to mechanical shock or vibration may alter the connection to an open circuit under low voltage excitation.

6.3.2 Inverted Waveform on M100 Detonator

The M100 detonator did not completely escape from notice due to odd waveforms. One M-100 detonator escaped notice on the first exposure to a current pulse (Figure 6-4A). This detonator is one of those which did not fire when exposed to the 90% firing current. It was subsequently re-examined using the same excitation level (60 mA) as used in the initial thermogram but with much different results (Figure 6-4B). Notice that the waveform is negative and of much greater amplitude than the initial waveform. After the detonator was dissectded and the explosive removed, a photomicrograph of the detonator was made (Figure 6-4C). The weld at the center electrode showed signs of expulsion and the electrode was deeply pitted.

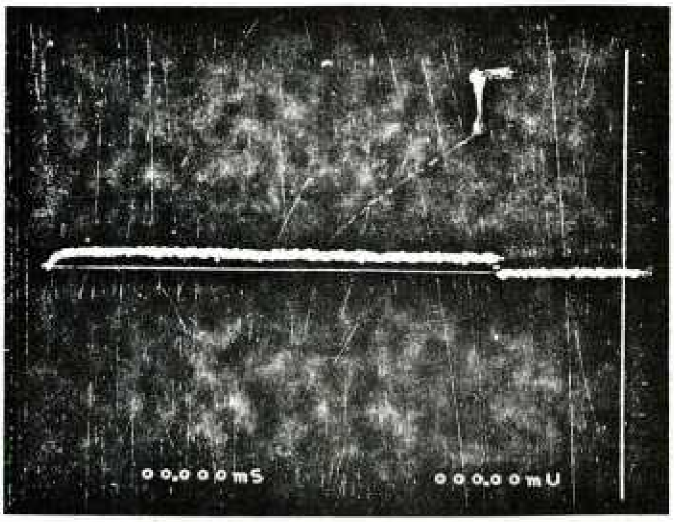
A- UNUSED HEADER- PA 506



B- ELECTROTHERMOGRAM OF UNUSED HEADER

Figure 6-3 Normal PA 506 Header

C-5174

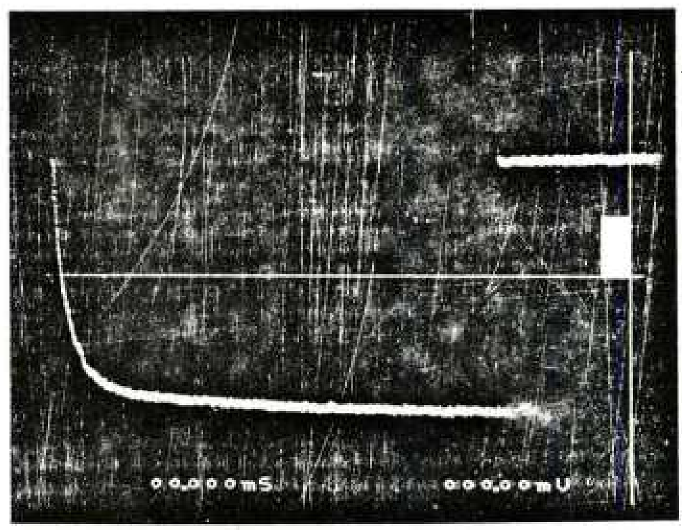


M 100- Initial Test

Presents a near-normal oscillogram.

AFTER EXPOSURE TO 90% FIRING CURRENT

The electrothermogram changes radically. The trace is negative and of much larger amplitude



EXPLOSIVE REMOVED

Photomicrograph of wire bridge shows that the center electrode was deeply pitted and that the weld showed signs of expulsion.

Figure 6-4 Anomoly in M 100 Detonator

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Progress has been made in demonstrating that an existing, commercially available electrothermal tester for electroexplosive devices does provide an inspection of EEDs that is meaningful. The electrothermal test reveals faults that other inspection methods have apparently missed. One major fault was easily discernable in each of the two detonator types tested and in one of the fuses.

There is apparently no hazard introduced by the instrument that was not present to begin with if all reasonable care is taken in use of the instrument.

Enough evidence is present in the work completed here to suspect a relationship between NDT determined parameters and detonator sensitivity. A numerical evaluation of the NDT parameter from items that either fired at the 10% excitation level or failed to fire at the 90% excitation level gave NDT readings that were indicative of their subsequent performance.

7.1 RECOMMENDATIONS

Since all of the items used in these tests were previously quality tested, we would expect the results that actually occurred. Only about 0.5% of the items tested showed abnormal performance in the form of severe distortion of the waveform. A large number of devices must be tested to find just a few items that are "bad" according to the electrothermal NDT technique. For this reason a large number of devices needs to be tested to provide additional confidence in the inspection method.

One positive step in this direction would permit a limited sampling of production lots of detonators. In the process, as much data as is practicable should be accumulated on production items. The "odd" waveform is a very important aspect of this method and detonators showing deviation from the normal waveform should be isolated, marked and inspected further.

Computations should be made on accumulated data in such a way that tested items can be recovered at a later date for re-inspection and possible test by firing.

EEDs with abnormal waveforms should be subject to inspection by other NDT methods, x-rays for example. This will allow a comparison of the electrothermal approach to other, currently used methods. Subsequent dissection and closer examination of devices in question may reveal the extent to which other NDT methods compare with the electrothermal method.

Our findings are that the NDT method is applicable, even if bridgewire materials have a relatively small temperature coefficient of resistance. Both the PA506 and M100 detonator use Moleculoy[R] as the bridgewire alloy. This material was apparently chosen for its very small alpha as well as for reasons unknown to us.

At some future date it may be prudent to use an alloy with a larger alpha. We feel that in many applications the choice of a larger alpha will permit electrothermal tests on EEDs that would otherwise be difficult to make.

Some foresight is now possible on future uses of the electrothermal test in the production of EEDs and our feeling is that such testing will be used eventually. There are a number of practices that will greatly aid the process:

- Design EEDs that contain bridgewires with higher values of alpha if this practice is compatible with other features of the system.
- Good electrical contact at the detonator input is a must, and efforts spent in producing and maintaining the contact will be well spent.
- While an analog approach will suffice in testing, a digital approach such as was used in this study produces much more information.
- Automation of the process is within realization. There will be small technical problems, mainly in decision making; but all of the technology exists for automated electrothermal measurements.
- Accept-reject criteria can be established by initial studies on production items, much the way the work reported here was done: establishing limits on thermal parameters, making use of algebraic sums of parameters combined with data derived from firings of samples of the EEDs.

We strongly recommend that this work be continued and that these inspection methods be applied to detonators and other EEDs that are being produced. To do otherwise is to invite accidents due to very sensitive detonators and failures due to very insensitive detonators or to improperly manufactured devices. We cannot afford to contend with the problems that the electrothermal test minimizes.

8. REFERENCES

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APPENDIX A

TEST PLAN FOR NONDESTRUCTIVE TESTS OF FUSES

PREPARED BY	DATE	THE FRANKLIN INSTITUTE FRANKLIN RESEARCH CENTER PHILADELPHIA, PA. 19103	PAGE
C.T. Davey	11/14/79		
APPROVED BY	DATE		PROJECT 03G-C5174-01

TITLE

TEST PLAN FOR NON-DESTRUCTIVE TESTS OF FUSES

1. Testing of Fuses

1.1 Obtain waveform from the Pasadena Tester at 20 milliampere test level and determine the thermal parameters using the data sheet provided. 100 fuses required.

1.2 Repeat 1.1 with test current of 25 milliamperes. 300 fuses required.

1.3 Repeat 1.1 with test current of 30 milliamperes. 100 fuses required.

Additional instructions on above.

A. Record any noticable differences in waveform, particularly distortions. Store on Floppy disks (FD) any vastly different waveforms and preserve for later analysis. Record the item number and FD location corresponding to the number.

B. Record representative sample of Waveforms
Obtain at least 20 oscillograms from each test, 1.1,1.2 and 1.3.

C. Remove only one fuse at a time from the coin envelope in which it is stored. Return the device to the same numbered envelope.

1.4 Methods to Cull

Review data from 1.1,1.2 and 1.3. Examine any waveforms that appear to be submormal and place such devices in a separate packet, recording their numbers.

Repeat electrothermal (ET) tests observing any waveform changes. These waveforms would have been recorded during the original tests so that comparisons can readily be made.

Select members of this group for microscopic examination. To examine them, remove the outer shell on a jeweler's lathe. View in optical microscope for any construction defects, comparing the questionable device with those found to be "normal". Those found to be defective or suspected of being defective by optical microscopic examination may be subjected to examination in the electron microscope.

Note: Numbers refer to the accompanying graphical test plan.

1.5 Quality Tests on NDT Items

Select a test current that insures opening of the fuse in a reasonable time frame. This may require some preliminary determinations using those remaining after removal of the 500 for NDT purposes. A plot of opening time vs current will be required.

Expose the items remaining from 1.1,1.2 and 1.3 to a fixed constant pulse, measuring opening time on a time interval meter. Record opening time for each item number tested.

1.6 Further NDT and Destructive Testing

This work is intended to be an extension of 1.4,methods to cull. The exact types of examination are not defined at this time. We plan to use the electron microscope in probing any devices that are, by previously mentioned methods, determined to be different or defective. These will be the -destructive portions of the testing on previously NDTd devices.

Non-destructive tests will be made by other methods that are currently not clear. One such method could be a continuous application of current with notation of the power required to raise the resistance a given amount.

1.7 Summary of Fuse Testing

A summary will be prepared on all of the testing done on the fuses. The results will be discussed by means of analysis, graphs and other illustrations to provide an understanding of what the results of the testing mean in terms of fuse quality.

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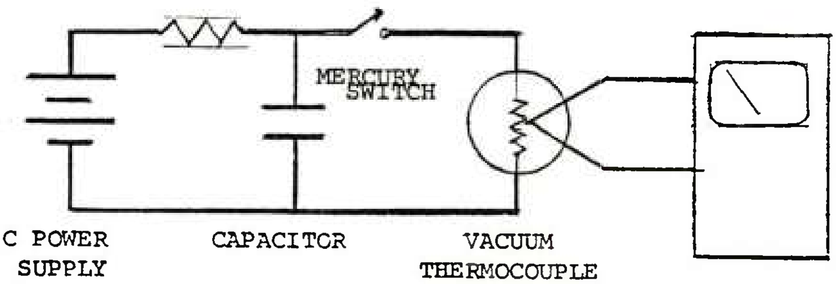
2. Study of Pasadena Electrothermal Tester (ETT)

2.1 Safety

The objective of this portion of the program is to determine any conditions under which the ETT becomes hazardous in the testing process.

To accomplish this, we will assemble an "ergmeter" that will in one sense act as the bridgewire of an electroexplosive device or as a thermal converter to allow broad viewing of the energy output of the tester. A sketch of the circuit is as follows:



The converter-integrator for energy is the vacuum thermocouple. Output from the thermocouple junction is in the form of a voltage signal that is proportional to the temperature of the heater element in the thermocouple. This element integrates the electrical input energy and presents it in the form of an output voltage that is read on the electronic microvolt-ammeter. The circuit to the left of the vacuum thermocouple provides for calibration of the system by providing a known energy input pulse.

The unit will be calibrated and then used to determine any stray energy output from the ETT. The effect of unbalance of the resistance bridge will be determined. Switching transients in variation of controls and switches will be investigated. Resolution is expected to be in the tens of ergs.

FORM 207 X 1.5M-4-74-CP

2.1 continued

Record settings and operations for which tests are made. If above-background readings are obtained, note the settings and conditions under which these signals appear. Investigate further , using oscillograms, to obtain the nature and source of such signals. Any readings that exceed 20 ergs should be considered potentially hazardous unless these energy levels can be explained as part of the intentionally provided test signal from the equipment.

Investigate, in particular the effects of reading resistance under off-balance conditions in the resistance measuring equipment (ETT). Record the off-balance setting and the energy output from the resultant pulse.

2.2 Accuracy

Obtain a precision resistance decade that reads to 0.01 ohm and covers a range from one ohm through 20 ohms. Set the decade to 5 ohms and read the value indicated on the ETT. Change the setting of the decade resistance to 6 ohms and observe the unbalance signal, recording the magnitude of the signal with the ETT. Cross-check the indicated signal against Vm and the test current. Continue this process in one-ohm steps comparing the resistance change indicated on the decade with that calculated from the oscilloscope trace. Tabulate and plot results. Measure the currents for resistance measurement (nominally 10 mA). Compare the pulse current indicated on the front panel with independently made measurements at the EED terminal.

Check the specifications of the equipment according to the instruction manual of the manufacturer. Note any differences between the specified value and that determined from experiment.

2.3 Operation

Check the operation of the equipment as specified in the manual provided by the manufacturer. Note any problems that are apparent or that could cause operational problems. These will become evident during exploration of the safety and accuracy portions of this work.

2.4 Precautions, Errors and Ancillary Equipment

Investigate further any safety, accuracy or equipment problems that are found to exist. Detail these and document them. From our findings, determine other commercially available ancillary equipment that would find potential use with the EED. For example, other oscilloscopes that may serve equally well.

3. Demonstrations

A demonstration and acceptance test will be planned and executed prior to completion of the contract. The test plan will be submitted 90 days prior to the planned acceptance test.

4. Final Report

A comprehensive final report will be prepared detailing all of the information determined during the course of the project.

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APPROVED BY	DATE	PHILADELPHIA, PA. 19103	PROJECT 03G-C5174-01

TITLE

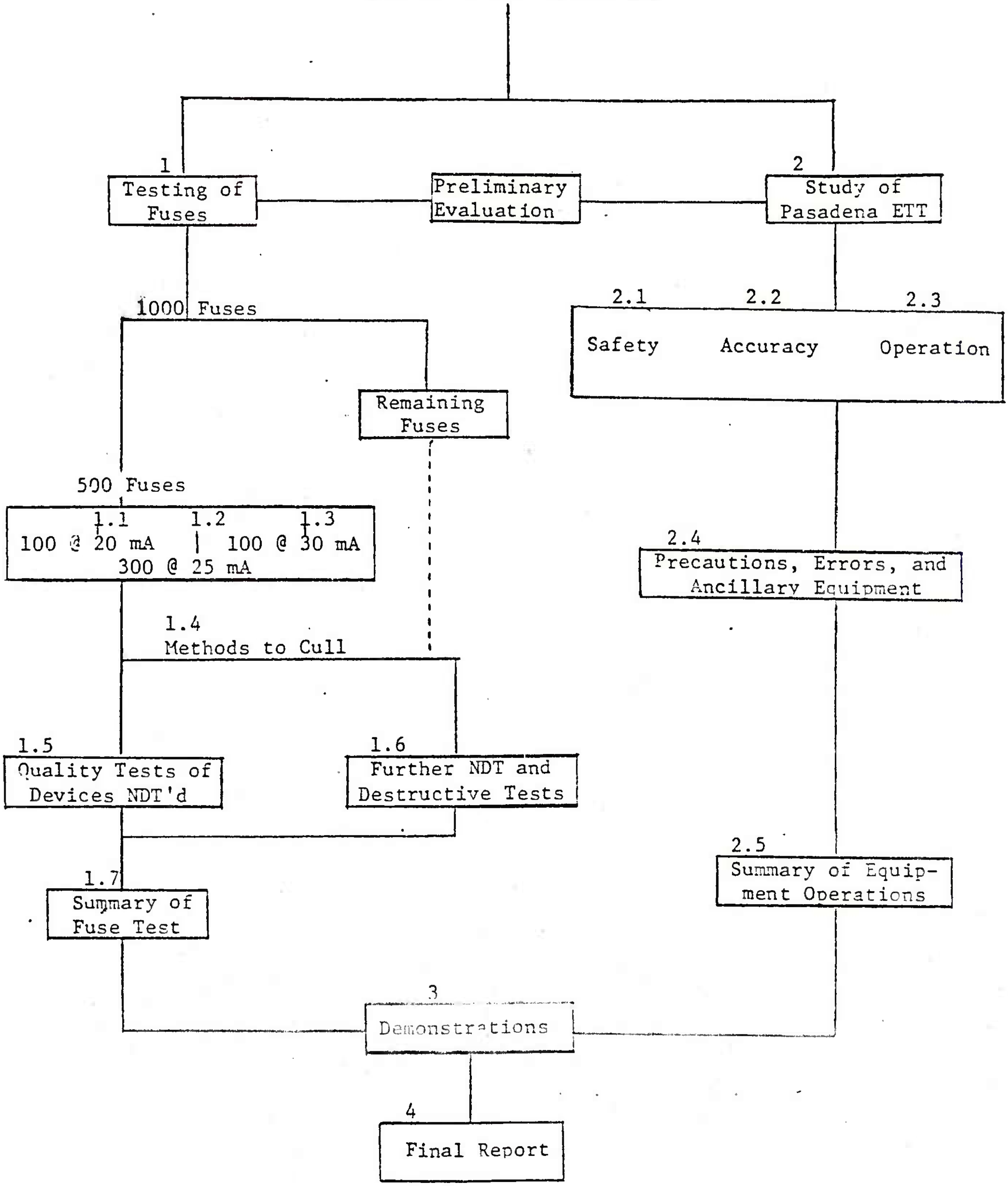
DATA SHEET FOR ELECTROTHERMAL ANALYSIS

TEST CURRENT ______ mA   PULSE TIME ________ ms   ITEM DESIGNATION________

ITEM NUMBER	INITIAL RESISTANCE R_o (ohms)	VOLTAGE INCREASE ΔV_m (mv)	THERMAL TIME CONST. τ (μsec)	INITIAL SLOPE $\Delta V/\Delta t$ (V/μsec)	OBSERVATIONS FLOPPY DISK NO. REMARKS

FORM 207 X 1.5M-4-74-CP

ELECTROTHERMAL ANALYTICAL RESPONSE INSPECTION
OF
ELECTROEXPLOSIVE DEVICES



APPENDIX B

NUMBERICAL RESULTS OF NONDESTRUCTIVE FUSE TESTING

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
1001	8.24	42.04	390	58.00	75.0	43	31	2.10	20
1002	6.80	21.50	335	36.00	46.5	58	34	1.08	20
1003	7.98	30.03	354	46.00	55.3	57	37	1.50	20
1004	8.97	38.89	263	73.00	63.8	56	29	1.94	20
1005	9.10	38.96	288	66.00	63.0	57	34	1.95	20
1006	9.15	35.63	337	54.00	57.2	63	42	1.78	20
1007	7.16	27.97	333	47.00	57.4	49	29	1.40	20
1008	9.37	27.21	198	65.00	42.7	87	36	1.36	20
1009	8.59	47.22	466	53.00	80.8	42	37	2.36	20
1010	9.35	27.28	183	71.00	42.9	87	33	1.36	20
1011	8.51	36.74	259	73.00	63.5	53	26	1.84	20
1012	8.97	48.37	302	79.00	79.3	45	27	2.42	20
1013	9.20	51.92	482	54.00	83.0	44	42	2.60	20
1014	9.00	57.10	411	71.00	93.3	38	31	2.85	20
1015	9.29	53.74	385	70.00	85.0	43	33	2.69	20
1016	9.62	60.43	334	89.00	92.4	41	28	3.02	20
1017	8.13	34.54	359	50.00	62.5	52	35	1.73	20
1018	7.77	32.70	455	38.00	61.9	50	43	1.63	20
1019	8.57	39.28	407	52.00	67.4	50	38	1.96	20
1020	7.93	39.63	325	72.00	73.5	43	23	1.98	20
1021	9.36	47.72	336	70.00	75.0	49	34	2.39	20
1022	7.19	16.59	258	36.00	33.9	84	39	0.83	20
1023	10.00	72.00	366	95.00	105.9	37	28	3.60	20
1024	8.98	34.83	362	49.00	57.0	62	44	1.74	20
1025	7.91	30.98	337	48.00	57.6	54	35	1.55	20
1026	7.96	22.90	228	51.00	42.3	75	33	1.14	20
1027	8.32	48.91	421	64.00	86.5	38	29	2.45	20
1028	9.02	55.35	417	68.00	90.2	39	32	2.77	20
1029	8.78	51.18	356	74.00	85.7	40	28	2.56	20
1030	8.49	43.45	363	61.00	75.3	45	32	2.17	20
1031	9.14	49.86	375	67.00	80.2	45	33	2.49	20
1032	8.67	49.01	424	60.00	83.1	41	34	2.45	20
1033	8.67	45.46	347	66.00	77.1	44	30	2.27	20
1034	9.43	63.83	458	70.00	99.5	37	34	3.19	20
1035	8.92	41.91	400	53.00	69.1	51	40	2.10	20
1036	9.31	54.74	427	65.00	86.5	43	36	2.74	20
1037	8.59	26.29	258	51.00	45.1	76	39	1.31	20
1038	9.56	36.87	287	62.00	56.7	67	40	1.84	20
1039	10.27	53.51	284	88.00	76.6	53	32	2.68	20
1040	8.05	33.84	300	59.00	61.8	52	29	1.69	20
1041	8.08	38.15	412	49.00	69.4	46	36	1.91	20
1042	7.30	21.97	272	43.00	44.3	65	33	1.10	20
1043	8.70	33.94	328	54.00	57.4	60	38	1.70	20
1044	8.99	43.87	288	75.00	71.8	50	29	2.19	20
1045	8.81	38.47	359	55.00	64.2	54	38	1.92	20
1046	9.58	38.08	324	58.00	58.5	65	43	1.90	20
1047	7.64	37.84	367	56.00	72.8	41	28	1.89	20
1048	9.42	61.95	427	74.00	96.7	38	32	3.10	20
1049	8.20	38.13	409	49.00	68.4	47	37	1.91	20
1050	8.68	39.98	321	63.00	67.7	51	32	2.00	20

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
1051	8.59	43.59	434	52.00	74.6	46	38	2.18	20
1052	8.06	24.92	235	54.00	45.5	70	32	1.25	20
1053	9.01	49.52	363	69.00	80.8	44	32	2.48	20
1054	8.31	42.39	412	54.00	75.0	44	34	2.12	20
1055	6.66	20.33	193	56.00	44.9	59	21	1.02	20
1056	9.27	42.97	342	63.00	68.2	54	37	2.15	20
1057	7.65	22.77	265	46.00	43.8	69	34	1.14	20
1058	8.47	48.30	397	63.00	83.9	40	30	2.41	20
1059	8.40	40.94	367	59.00	71.7	46	32	2.05	20
1060	8.52	23.34	265	45.00	40.3	84	43	1.17	20
1061	8.28	31.44	308	54.00	55.8	59	34	1.57	20
1062	7.27	33.94	422	44.00	68.6	42	32	1.70	20
1063	7.79	37.36	427	48.00	70.5	44	34	1.87	20
1064	7.82	33.15	436	41.00	62.3	50	40	1.66	20
1065	9.71	68.99	432	79.00	104.5	37	32	3.45	20
1066	8.42	38.04	272	70.00	66.4	50	27	1.90	20
1067	7.93	33.35	345	50.00	61.8	51	34	1.67	20
1068	9.26	46.13	291	78.00	73.3	50	29	2.31	20
1069	8.52	46.21	375	64.00	79.8	42	30	2.31	20
1070	8.18	29.09	294	52.00	52.3	62	35	1.45	20
1071	8.31	34.33	258	68.00	60.8	54	27	1.72	20
1072	6.79	28.12	391	40.00	60.9	44	31	1.41	20
1073	8.15	35.85	356	52.00	64.7	50	34	1.79	20
1074	8.10	32.94	358	48.00	59.8	54	37	1.65	20
1075	7.14	30.08	308	54.00	62.0	46	25	1.50	20
1076	9.99	57.07	259	104.00	84.0	47	26	2.85	20
1077	7.31	23.46	324	39.00	47.2	61	37	1.17	20
1078	9.16	55.28	447	63.00	88.7	41	36	2.76	20
1079	9.27	40.08	318	63.00	63.6	58	37	2.00	20
1080	6.96	30.36	270	62.00	64.1	43	21	1.52	20
1081	9.46	48.46	370	65.00	75.3	50	37	2.42	20
1082	8.74	22.02	374	33.00	37.0	94	62	1.10	20
1083	9.34	52.70	304	84.00	83.0	45	28	2.64	20
1084	8.45	33.86	332	52.00	58.9	57	37	1.69	20
1085	9.24	48.58	382	64.00	77.3	47	36	2.43	20
1086	8.06	35.76	277	68.00	65.2	49	25	1.79	20
1087	7.57	32.59	441	40.00	63.3	47	38	1.63	20
1088	8.27	38.46	372	54.00	68.4	46	34	1.92	20
1089	7.16	40.41	345	65.00	83.0	34	21	2.02	20
1090	8.23	35.64	362	50.00	63.7	51	36	1.78	20
1091	6.64	25.38	271	51.00	56.2	47	23	1.27	20
1092	9.14	51.20	338	77.00	82.4	44	29	2.56	20
1093	7.34	23.84	322	41.00	47.8	61	35	1.19	20
1094	7.50	28.35	367	43.00	55.6	53	35	1.42	20
1095	8.09	29.76	269	57.00	54.1	59	31	1.49	20
1096	8.47	40.36	406	53.00	70.1	48	36	2.02	20
1097	8.08	37.43	311	63.00	68.1	47	28	1.87	20
1098	9.69	55.53	384	74.00	84.3	45	34	2.78	20
1099	10.38	55.64	254	99.00	78.8	52	29	2.78	20
1100	7.95	24.77	277	49.00	45.8	69	35	1.24	20

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TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
2001	7.76	76.46	290	183.00	115.9	41	17	3.06	25
2002	8.32	104.24	340	188.00	147.4	35	19	4.17	25
2003	6.77	64.31	399	125.00	111.8	37	19	2.57	25
2004	8.49	109.09	351	211.00	151.2	35	18	4.36	25
2005	8.16	84.08	330	159.00	121.2	42	22	3.36	25
2006	9.23	85.96	403	146.00	109.6	52	30	3.44	25
2007	7.77	94.71	370	169.00	143.4	33	18	3.79	25
2008	8.06	110.89	501	140.00	161.9	31	24	4.44	25
2009	8.13	96.54	394	144.00	139.7	36	24	3.86	25
2010	6.85	66.05	413	102.00	113.4	37	24	2.64	25
2011	8.65	114.88	420	158.00	156.3	34	25	4.60	25
2012	8.76	114.62	367	174.00	153.9	35	23	4.58	25
2013	7.91	84.93	421	133.00	126.3	39	24	3.40	25
2014	9.05	102.30	352	171.00	133.0	42	25	4.09	25
2015	7.40	74.38	380	128.00	118.3	39	22	2.98	25
2016	8.20	99.01	391	149.00	142.0	36	23	3.96	25
2017	7.03	65.31	363	112.00	109.3	40	23	2.61	25
2018	7.51	58.75	299	114.00	92.0	51	26	2.35	25
2019	8.54	115.13	376	178.00	158.6	33	21	4.61	25
2020	8.25	75.10	267	156.00	107.1	48	23	3.00	25
2021	7.99	110.10	484	147.00	162.1	30	23	4.40	25
2022	7.58	63.82	308	121.00	99.0	47	25	2.55	25
2023	7.71	90.32	369	143.00	137.8	34	22	3.61	25
2024	7.86	64.39	342	110.00	96.4	50	29	2.58	25
2025	7.36	72.74	365	130.00	116.3	39	22	2.91	25
2026	8.07	94.05	365	148.00	137.1	36	23	3.76	25
2027	9.18	142.03	410	188.00	182.0	31	23	5.68	25
2028	8.14	73.29	521	113.00	105.9	48	31	2.93	25
2029	7.29	68.21	316	129.00	110.1	41	21	2.73	25
2030	8.28	122.02	560	140.00	173.4	29	26	4.88	25
2031	8.73	117.91	416	165.00	158.9	34	24	4.72	25
2032	9.28	137.76	398	189.00	174.6	33	24	5.51	25
2033	7.23	77.19	438	114.00	125.6	35	24	3.09	25
2034	8.31	98.69	372	154.00	139.7	37	23	3.95	25
2035	6.96	59.61	370	102.00	100.8	43	25	2.38	25
2036	8.04	81.09	322	151.00	118.7	42	22	3.24	25
2037	9.16	117.83	364	176.00	151.3	37	25	4.71	25
2038	7.07	48.05	271	110.00	80.0	55	24	1.92	25
2039	9.53	175.28	544	191.00	216.4	27	25	7.01	25
2040	8.06	88.31	388	136.00	128.9	39	25	3.53	25
2041	9.21	115.64	373	176.00	147.7	38	25	4.63	25
2042	7.02	69.95	409	111.00	117.2	37	23	2.80	25
2043	9.01	104.46	421	140.00	136.4	41	30	4.18	25
2044	9.14	134.94	465	168.00	173.7	32	26	5.40	25
2045	7.76	89.95	433	137.00	136.4	35	23	3.60	25
2046	7.98	126.76	465	162.00	186.9	26	20	5.07	25
2047	7.42	70.29	319	136.00	111.4	41	21	2.81	25
2048	7.54	92.61	308	181.00	141.5	32	16	3.70	25
2049	8.11	154.37	549	184.00	215.9	24	20	6.17	25
2050	7.27	78.41	309	149.00	126.9	35	18	3.14	25

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
2051	7.74	90.30	317	177.00	137.2	35	17	3.61	25
2052	6.92	72.33	315	149.00	123.0	35	17	2.89	25
2053	8.22	87.18	279	175.00	124.8	41	20	3.49	25
2054	9.82	183.73	460	200.00	220.1	27	25	7.35	25
2055	8.38	161.47	427	231.00	226.7	23	16	6.46	25
2056	7.17	45.41	209	128.00	74.5	60	21	1.82	25
2057	8.17	84.94	270	175.00	122.3	41	20	3.40	25
2058	8.28	99.72	342	169.00	141.7	36	21	3.99	25
2059	8.59	107.54	371	163.00	147.3	36	24	4.30	25
2060	7.23	52.98	257	120.00	86.2	52	23	2.12	25
2061	8.05	102.07	406	164.00	149.2	33	20	4.08	25
2062	9.33	153.87	336	253.00	194.0	30	18	6.15	25
2063	9.10	136.28	454	179.00	176.2	32	24	5.45	25
2064	8.92	156.66	583	166.00	206.6	26	25	6.27	25
2065	8.54	83.71	286	161.00	115.3	46	24	3.35	25
2066	9.01	147.33	381	213.00	192.4	29	20	5.89	25
2067	8.96	170.83	503	211.00	224.3	24	20	6.83	25
2068	6.71	69.60	419	116.00	122.0	34	20	2.78	25
2069	7.29	68.12	321	130.00	109.9	41	21	2.72	25
2070	7.72	92.59	396	141.00	141.1	34	22	3.70	25
2071	8.08	96.28	430	133.00	140.2	36	26	3.85	25
2072	8.92	110.68	278	214.00	146.0	38	19	4.43	25
2073	9.13	167.77	419	232.00	216.2	26	19	6.71	25
2074	8.13	105.52	370	171.00	152.7	33	20	4.22	25
2075	7.72	109.51	430	156.00	166.9	28	20	4.38	25
2076	8.36	108.14	408	158.00	152.2	34	23	4.33	25
2077	7.65	78.19	306	150.00	120.2	39	20	3.13	25
2078	9.99	208.70	509	237.00	245.8	25	22	8.35	25
2079	8.20	128.86	524	149.00	184.9	27	23	5.15	25
2080	10.37	249.33	618	221.00	282.9	22	25	9.97	25
2081	8.68	162.52	523	183.00	220.3	24	21	6.50	25
2082	8.84	134.61	447	188.00	179.1	30	22	5.38	25
2083	7.61	54.06	268	130.00	83.6	56	23	2.16	25
2084	8.29	119.98	439	173.00	170.3	30	21	4.80	25
2085	7.73	106.65	501	148.00	162.3	29	21	4.27	25
2086	8.08	104.05	486	137.00	151.5	33	25	4.16	25
2087	7.91	77.28	350	131.00	114.9	43	25	3.09	25
2088	7.60	68.20	359	116.00	105.6	44	26	2.73	25
2089	8.21	111.26	389	176.00	159.4	32	20	4.45	25
2090	8.72	114.47	353	178.00	154.4	35	22	4.58	25
2091	7.99	104.79	381	160.00	154.3	32	21	4.19	25
2092	6.96	98.71	380	160.00	166.8	26	16	3.95	25
2093	7.86	72.24	257	158.00	108.1	45	20	2.89	25
2094	7.79	91.80	336	172.00	138.6	35	18	3.67	25
2095	7.75	69.23	350	119.00	105.1	46	26	2.77	25
2096	8.90	133.91	444	173.00	177.0	31	24	5.36	25
2097	9.33	160.73	510	186.00	202.7	28	24	6.43	25
2098	8.19	95.50	339	159.00	137.2	37	22	3.82	25
2099	9.80	199.78	635	185.00	239.8	25	27	7.99	25
2100	8.43	98.97	330	172.00	138.1	38	21	3.96	25

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C'	nwatt-sec/C'	ohms	ma
2101	7.28	67.22	322	125.00	108.6	41	22	2.69	25
2102	8.13	123.10	457	166.00	178.1	28	21	4.92	25
2103	7.62	91.27	383	159.00	140.9	33	19	3.65	25
2104	8.80	140.25	499	165.00	187.5	29	24	5.61	25
2105	7.52	87.78	413	133.00	137.3	34	22	3.51	25
2106	7.52	82.34	392	129.00	128.8	36	23	3.29	25
2107	8.42	96.24	410	149.00	134.5	39	25	3.85	25
2108	8.50	96.85	392	142.00	134.0	39	27	3.87	25
2109	8.86	45.45	261	85.00	60.4	91	49	1.82	25
2110	9.14	125.75	431	168.00	161.9	35	26	5.03	25
2111	7.43	78.87	313	146.00	124.9	37	20	3.15	25
2112	7.71	57.73	266	124.00	88.1	54	25	2.31	25
2113	9.01	136.49	476	172.00	178.2	31	25	5.46	25
2114	8.57	99.63	360	157.00	136.8	39	24	3.99	25
2115	8.31	119.47	457	155.00	169.1	30	23	4.78	25
2116	7.40	73.95	329	141.00	117.6	39	20	2.96	25
2117	7.68	88.31	402	131.00	135.3	35	23	3.53	25
2118	8.32	93.62	338	167.00	132.4	39	22	3.74	25
2119	8.97	112.87	378	175.00	148.0	37	24	4.51	25
2120	9.47	126.75	322	209.00	157.5	37	22	5.07	25
2121	7.44	78.83	265	179.00	124.7	37	16	3.15	25
2122	8.70	124.45	413	170.00	168.3	32	23	4.98	25
2123	8.28	85.28	311	159.00	121.2	42	22	3.41	25
2124	8.46	79.56	264	147.00	110.6	47	25	3.18	25
2125	8.37	125.74	477	153.00	176.7	29	24	5.03	25
2126	8.74	126.21	456	161.00	169.9	32	25	5.05	25
2127	8.10	82.08	298	151.00	119.2	42	23	3.28	25
2128	8.79	150.41	577	160.00	201.3	27	25	6.02	25
2129	8.07	74.36	326	132.00	108.4	46	26	2.97	25
2130	8.10	88.42	323	167.00	128.4	39	20	3.54	25
2131	8.73	117.91	416	165.00	158.9	34	24	4.72	25
2132	9.28	137.76	398	189.00	174.6	33	24	5.51	25
2133	7.23	77.19	438	114.00	125.6	35	24	3.09	25
2134	8.31	98.69	372	154.00	139.7	37	23	3.95	25
2135	6.96	59.61	370	102.00	100.8	43	25	2.38	25
2136	8.04	81.09	322	151.00	118.7	42	22	3.24	25
2137	9.16	117.83	364	176.00	151.3	37	25	4.71	25
2138	7.07	48.05	271	110.00	80.0	55	24	1.92	25
2139	9.53	175.28	544	191.00	216.4	27	25	7.01	25
2140	8.06	88.31	388	136.00	128.9	39	25	3.53	25
2141	7.61	92.63	491	118.00	143.2	33	26	3.71	25
2142	7.47	94.25	367	157.00	148.4	31	18	3.77	25
2143	8.01	109.59	462	150.00	161.0	31	22	4.38	25
2144	8.22	76.25	280	161.00	109.1	47	22	3.05	25
2145	7.76	102.30	425	143.00	155.1	31	22	4.09	25
2146	7.40	75.08	400	133.00	119.4	38	21	3.00	25
2147	8.27	108.07	421	162.00	153.7	33	22	4.32	25
2148	7.78	100.01	405	155.00	151.2	32	20	4.00	25
2149	6.80	66.44	368	118.00	115.0	36	20	2.66	25
2150	8.95	150.84	451	202.00	198.3	28	21	6.03	25

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C'	nwatt-sec/C'	ohms	ma
2151	8.79	125.24	393	182.00	167.6	32	22	5.01	25
2152	8.85	130.91	501	152.00	174.0	31	27	5.24	25
2153	8.15	76.96	312	144.00	111.1	45	24	3.08	25
2154	8.92	141.71	455	188.00	186.9	29	22	5.67	25
2155	8.18	112.44	474	143.00	161.7	31	24	4.50	25
2156	7.07	74.17	355	129.00	123.4	35	20	2.97	25
2157	8.99	141.19	501	164.00	184.8	30	26	5.65	25
2158	8.61	142.09	442	184.00	194.1	27	21	5.68	25
2159	8.76	86.30	387	131.00	115.9	47	31	3.45	25
2160	8.60	139.87	528	159.00	191.3	28	24	5.59	25
2161	9.89	132.77	371	204.00	157.9	39	25	5.31	25
2162	8.84	141.11	461	175.00	187.8	29	23	5.64	25
2163	7.54	82.00	432	117.00	127.9	36	25	3.28	25
2164	9.14	145.94	491	169.00	187.9	30	26	5.84	25
2165	9.24	141.51	510	163.00	180.2	32	27	5.66	25
2166	8.70	123.79	493	147.00	167.4	32	27	4.95	25
2167	7.85	106.48	412	159.00	159.6	30	20	4.26	25
2168	9.61	172.57	415	236.00	211.3	28	20	6.90	25
2169	8.47	96.69	306	185.00	134.3	39	20	3.87	25
2170	8.12	81.81	275	170.00	118.5	42	20	3.27	25
2171	7.69	70.85	342	128.00	108.4	44	24	2.83	25
2172	8.72	130.57	434	172.00	176.2	30	23	5.22	25
2173	7.81	108.82	428	164.00	163.9	29	19	4.35	25
2174	7.86	73.40	292	141.00	109.9	44	23	2.94	25
2175	7.90	106.95	416	161.00	159.3	31	20	4.28	25
2176	8.26	126.27	521	158.00	179.8	28	22	5.05	25
2177	6.77	59.03	326	117.00	102.6	41	20	2.36	25
2178	7.18	68.72	405	105.00	112.6	39	26	2.75	25
2179	9.04	140.61	457	175.00	183.0	30	24	5.62	25
2180	8.69	134.47	405	185.00	182.1	29	21	5.38	25
2181	9.47	187.20	528	200.00	232.6	25	23	7.49	25
2182	7.63	80.04	330	144.00	123.4	38	21	3.20	25
2183	8.01	69.61	365	116.00	102.2	48	29	2.78	25
2184	7.47	76.43	400	116.00	120.4	38	25	3.06	25
2185	8.19	101.41	366	162.00	145.7	35	21	4.06	25
2186	7.31	56.17	325	117.00	90.4	50	24	2.25	25
2187	7.77	93.83	386	147.00	142.1	34	21	3.75	25
2188	9.34	164.97	491	190.00	207.8	28	24	6.60	25
2189	8.74	138.68	480	173.00	186.7	29	23	5.55	25
2190	8.65	129.80	398	187.00	176.5	30	21	5.19	25
2191	7.86	86.17	379	151.00	129.0	38	21	3.45	25
2192	8.74	87.05	304	148.00	117.2	46	27	3.48	25
2193	8.68	109.09	339	183.00	147.9	36	21	4.36	25
2194	7.54	72.97	345	128.00	113.8	41	23	2.92	25
2195	9.82	117.73	312	191.00	141.0	43	26	4.71	25
2196	9.88	228.22	624	205.00	271.8	22	25	9.13	25
2197	9.53	145.99	371	232.00	180.2	33	22	5.84	25
2198	8.47	99.65	382	165.00	138.4	38	23	3.99	25
2199	10.00	171.20	346	262.00	201.4	31	20	6.85	25
2200	7.00	64.60	379	108.00	108.6	40	24	2.58	25

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
2201	9.64	145.53	433	199.00	177.6	33	24	5.82	25
2202	8.22	100.85	401	148.00	144.3	35	24	4.03	25
2203	8.15	106.81	374	174.00	154.2	33	20	4.27	25
2204	8.98	154.50	521	172.00	202.4	27	24	6.18	25
2205	8.22	61.95	221	148.00	88.7	57	24	2.48	25
2206	9.27	109.55	321	194.00	139.0	41	23	4.38	25
2207	10.08	220.18	586	225.00	257.0	24	23	8.81	25
2208	8.14	91.52	289	173.00	132.3	38	20	3.66	25
2209	8.34	130.67	500	168.00	184.3	28	21	5.23	25
2210	8.82	120.64	411	171.00	160.9	34	24	4.83	25
2211	8.88	145.00	449	195.00	192.1	28	21	5.80	25
2212	8.40	100.83	414	142.00	141.2	37	26	4.03	25
2213	9.00	130.82	467	162.00	171.0	32	26	5.23	25
2214	8.53	84.96	368	135.00	117.2	45	28	3.40	25
2215	7.99	96.88	394	146.00	142.6	35	23	3.88	25
2216	9.84	168.04	419	212.00	200.9	30	24	6.72	25
2217	6.60	59.68	383	104.00	106.4	38	22	2.39	25
2218	7.91	89.82	434	136.00	133.6	37	24	3.59	25
2219	7.99	94.00	406	140.00	138.4	36	24	3.76	25
2220	8.25	90.06	364	150.00	128.4	40	24	3.60	25
2221	8.14	88.34	445	124.00	127.7	39	28	3.53	25
2222	7.83	80.41	388	127.00	120.8	40	25	3.22	25
2223	8.60	112.34	377	182.00	153.7	34	21	4.49	25
2224	8.65	124.30	477	151.00	169.1	31	26	4.97	25
2225	8.71	118.06	415	164.00	159.5	34	24	4.72	25
2226	9.28	117.90	318	194.00	149.5	38	23	4.72	25
2227	7.92	63.44	293	134.00	94.2	52	24	2.54	25
2228	6.68	36.11	194	105.00	63.6	65	22	1.44	25
2229	8.79	91.23	301	166.00	122.1	44	24	3.65	25
2230	7.49	57.63	284	119.00	90.5	51	25	2.31	25
2231	7.46	65.48	345	116.00	103.3	45	25	2.62	25
2232	9.34	134.61	318	232.00	169.6	34	19	5.38	25
2233	8.20	89.45	337	161.00	128.3	39	22	3.58	25
2234	9.39	147.75	488	171.00	185.1	31	27	5.91	25
2235	7.66	74.44	426	109.00	114.3	41	28	2.98	25
2236	7.08	51.92	294	105.00	86.3	51	25	2.08	25
2237	10.42	155.09	324	241.00	175.1	37	23	6.20	25
2238	7.94	83.60	422	121.00	123.9	40	27	3.34	25
2239	9.46	126.78	349	196.00	157.7	37	24	5.07	25
2240	7.98	77.94	334	144.00	114.9	43	23	3.12	25
2241	8.54	104.38	426	150.00	143.8	37	25	4.18	25
2242	8.72	113.16	429	159.00	152.7	35	25	4.53	25
2243	8.46	84.82	433	121.00	118.0	44	31	3.39	25
2244	7.82	85.80	387	132.00	129.1	37	24	3.43	25
2245	8.63	126.50	341	214.00	172.4	31	18	5.06	25
2246	8.08	75.12	346	134.00	109.4	46	25	3.00	25
2247	9.20	102.91	322	174.00	131.6	43	25	4.12	25
2248	8.84	126.23	462	156.00	168.0	32	26	5.05	25
2249	9.03	89.44	352	148.00	116.5	48	29	3.58	25
2250	7.73	68.26	257	147.00	103.9	46	21	2.73	25

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
2251	7.06	69.18	372	115.00	115.3	38	23	2.77	25
2252	7.63	72.02	361	121.00	111.0	42	25	2.88	25
2253	7.77	68.24	270	152.00	103.3	47	21	2.73	25
2254	6.98	70.04	376	122.00	118.1	36	21	2.80	25
2255	8.06	104.66	371	165.00	152.8	32	20	4.19	25
2256	9.76	124.49	260	244.00	150.1	40	20	4.98	25
2257	8.47	116.18	412	162.00	161.4	32	23	4.65	25
2258	8.11	77.78	383	124.00	112.8	44	28	3.11	25
2259	7.08	67.21	354	120.00	111.7	39	22	2.69	25
2260	7.14	54.59	331	111.00	86.3	53	26	2.18	25
2261	7.18	63.82	377	105.00	104.6	42	26	2.55	25
2262	8.50	109.52	483	149.00	151.6	35	25	4.38	25
2263	8.43	113.07	510	133.00	157.8	33	28	4.52	25
2264	7.20	73.19	445	105.00	119.6	37	26	2.93	25
2265	6.82	59.46	380	100.00	102.6	41	24	2.38	25
2266	8.58	53.79	314	102.00	73.8	72	38	2.15	25
2267	8.40	100.74	344	164.00	141.1	37	22	4.03	25
2268	7.81	58.51	283	122.00	88.1	55	26	2.34	25
2269	6.85	55.61	313	108.00	95.5	44	23	2.22	25
2270	7.13	65.01	2082	97.00	107.3	41	27	2.60	25
2271	7.85	98.53	471	127.00	147.7	33	25	3.94	25
2272	8.59	124.00	395	181.00	169.8	31	21	4.96	25
2273	9.12	141.30	420	202.00	182.3	31	21	5.65	25
2274	9.78	101.41	384	148.00	135.9	40	27	4.06	25
2275	7.42	82.40	388	132.00	130.6	35	22	3.30	25
2276	9.68	165.80	583	175.00	201.5	30	28	6.63	25
2277	8.53	117.11	440	159.00	161.5	33	24	4.68	25
2278	8.46	113.90	437	151.00	158.4	33	25	4.56	25
2279	7.92	90.23	361	148.00	134.0	36	22	3.61	25
2280	8.42	78.56	356	132.00	109.8	47	28	3.14	25
2281	9.69	190.01	510	205.00	230.7	26	24	7.60	25
2282	10.11	136.65	473	159.00	159.0	39	34	5.47	25
2283	7.62	94.62	432	148.00	146.1	32	20	3.78	25
2284	8.22	102.49	449	138.00	146.7	35	26	4.10	25
2285	8.09	86.02	351	146.00	125.1	40	23	3.44	25
2286	7.52	55.54	281	115.00	86.9	54	26	2.22	25
2287	7.16	66.32	357	127.00	109.0	41	21	2.65	25
2288	9.60	89.67	440	114.00	109.9	54	42	3.59	25
2289	8.44	93.12	423	130.00	129.8	40	29	3.72	25
2290	9.16	128.28	459	163.00	164.8	34	27	5.13	25
2291	8.18	98.17	440	133.00	141.2	36	26	3.93	25
2292	8.39	100.87	427	138.00	141.4	37	27	4.03	25
2293	8.05	81.32	356	144.00	118.8	42	23	3.25	25
2294	7.45	89.17	483	123.00	140.8	33	23	3.57	25
2295	7.04	73.70	373	125.00	123.2	35	21	2.95	25
2296	8.22	86.00	349	144.00	123.1	41	24	3.44	25
2297	8.43	106.25	427	143.00	148.3	35	26	4.25	25
2298	7.41	91.32	383	148.00	145.0	31	19	3.65	25
2299	7.95	74.76	339	129.00	110.6	44	26	2.99	25
2300	8.52	71.49	239	163.00	98.7	53	23	2.86	25

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE ohms	MAXIMUM VOLTAGE mv	THERMAL TIME-CONST usec	INITIAL SLOPE v/sec	THETA degrees C	GAMMA uwatts/C°	THERMAL CAPACITY uwatt-sec/C°	RESISTANCE CHANGE ohms	PULSE CURRENT ma
3001	7.70	209.66	551	231.00	266.9	25	23	6.99	30
3002	8.54	249.92	617	250.00	286.9	26	26	8.33	30
3003	8.61	314.88	639	302.00	358.5	21	22	10.50	30
3004	7.62	195.41	569	214.00	251.4	27	24	6.51	30
3005	7.68	181.57	499	224.00	231.8	29	24	6.05	30
3006	6.90	138.92	363	232.00	197.4	31	18	4.63	30
3007	8.46	225.58	404	290.00	261.4	29	22	7.52	30
3008	9.07	493.91	792	392.00	533.9	15	19	16.46	30
3009	9.67	276.95	620	348.00	280.8	30	24	9.23	30
3010	8.01	81.41	219	230.00	99.6	72	25	2.71	30
3011	7.55	189.19	586	208.00	245.7	27	25	6.31	30
3012	7.47	95.91	277	196.00	125.9	53	26	3.20	30
3013	7.57	169.90	496	212.00	220.0	30	24	5.66	30
3014	6.78	117.80	389	188.00	170.3	35	22	3.93	30
3015	7.94	198.06	536	226.00	244.6	29	25	6.60	30
3016	7.48	189.83	431	258.00	248.8	27	19	6.33	30
3017	7.06	134.60	422	190.00	186.9	33	24	4.49	30
3018	9.78	368.50	470	394.00	369.4	23	22	12.28	30
3019	8.43	256.91	798	256.00	298.8	25	25	8.56	30
3020	6.80	185.30	451	262.00	267.2	22	16	6.18	30
3021	7.50	140.35	461	186.00	183.5	36	27	4.68	30
3022	7.60	169.14	445	238.00	218.2	31	22	5.64	30
3023	6.68	172.30	415	256.00	252.9	23	16	5.74	30
3024	9.69	478.27	785	350.00	483.9	18	24	15.94	30
3025	8.36	326.26	641	296.00	382.6	19	21	10.88	30
3026	7.97	271.35	616	266.00	333.8	21	21	9.04	30
3027	8.95	289.18	664	248.00	316.8	25	29	9.64	30
3028	9.16	521.92	883	334.00	558.6	14	23	17.40	30
3029	9.06	394.35	773	302.00	426.7	19	24	13.15	30
3030	8.73	241.80	466	318.00	271.5	28	22	8.06	30
3031	7.63	207.68	471	262.00	266.9	25	20	6.92	30
3032	7.83	236.25	622	238.00	295.8	23	23	7.87	30
3033	7.54	167.33	457	246.00	217.6	31	21	5.58	30
3034	7.99	195.55	420	272.00	239.9	29	21	6.52	30
3035	7.73	246.80	669	228.00	313.0	22	24	8.23	30
3036	8.27	196.77	445	270.00	233.3	31	23	6.56	30
3037	7.30	122.83	308	230.00	165.0	39	21	4.09	30
3038	8.32	277.00	552	290.00	326.4	22	21	9.23	30
3039	7.76	223.07	518	264.00	281.8	24	20	7.44	30
3040	7.06	143.30	351	242.00	199.0	31	18	4.78	30
3041	8.32	235.60	564	244.00	277.6	26	26	7.85	30
3042	6.96	147.72	431	212.00	208.1	30	20	4.92	30
3043	6.94	179.90	587	204.00	254.1	24	21	6.00	30
3044	6.77	54.33	156	202.00	78.7	77	20	1.81	30
3045	7.77	240.96	489	296.00	304.0	23	18	8.03	30
3046	8.67	331.39	649	296.00	374.7	20	23	11.05	30
3047	8.82	362.10	712	296.00	402.5	19	24	12.07	30
3048	7.88	190.06	435	256.00	236.5	29	22	6.34	30
3049	8.98	475.07	765	360.00	518.7	15	20	15.84	30
3050	9.65	288.46	535	300.00	293.1	29	28	9.62	30

*** SCD 10383 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
3051	8.94	462.33	829	326.00	507.0	15	22	15.41	30
3052	8.93	388.82	760	320.00	426.9	18	22	12.96	30
3053	8.56	219.56	515	268.00	251.5	30	25	7.32	30
3054	9.54	440.04	669	350.00	452.2	18	23	14.67	30
3055	6.78	158.24	469	214.00	228.8	26	19	5.27	30
3056	9.14	217.62	325	348.00	233.4	35	22	7.25	30
3057	8.32	190.53	395	272.00	224.5	33	23	6.35	30
3058	8.22	280.59	601	274.00	334.7	22	22	9.35	30
3059	9.03	321.80	573	312.00	349.4	23	23	10.73	30
3060	7.06	179.98	491	242.00	249.9	25	18	6.00	30
3061	10.32	575.87	729	412.00	547.1	16	23	19.20	30
3062	9.48	529.47	920	356.00	547.6	15	23	17.65	30
3063	7.27	126.24	370	200.00	170.2	38	24	4.21	30
3064	8.32	280.48	607	278.00	330.5	22	22	9.35	30
3065	7.60	181.98	479	244.00	234.8	29	21	6.07	30
3066	7.32	194.16	447	260.00	260.0	25	18	6.47	30
3067	8.88	322.47	569	328.00	356.0	22	22	10.75	30
3068	8.04	248.05	678	222.00	302.5	23	26	8.27	30
3069	9.07	362.90	631	314.00	392.3	20	24	12.10	30
3070	7.49	129.95	345	230.00	170.1	39	22	4.33	30
3071	9.32	340.80	590	330.00	358.5	23	24	11.36	30
3072	7.51	236.03	470	296.00	308.1	21	17	7.87	30
3073	7.07	177.53	577	196.00	246.2	25	23	5.92	30
3074	8.71	252.02	540	278.00	283.7	27	25	8.40	30
3075	9.36	234.84	451	298.00	246.0	34	26	7.83	30
3076	8.87	327.02	606	310.00	361.4	22	23	10.90	30
3077	9.02	233.19	470	294.00	253.5	32	25	7.77	30
3078	8.23	214.38	424	292.00	255.4	29	21	7.15	30
3079	7.95	200.14	494	246.00	246.8	28	23	6.67	30
3080	8.79	172.12	310	298.00	192.0	41	23	5.74	30
3081	8.16	334.13	751	270.00	387.2	19	24	11.14	30
3082	6.78	86.58	245	206.00	125.2	48	20	2.89	30
3083	9.85	472.83	649	396.00	470.6	18	22	15.76	30
3084	8.46	169.83	309	300.00	196.8	38	21	5.66	30
3085	8.32	300.08	628	300.00	353.6	21	21	10.00	30
3086	7.12	123.95	388	196.00	170.7	37	23	4.13	30
3087	9.39	158.80	393	204.00	165.8	50	39	5.29	30
3088	7.95	187.76	406	286.00	231.5	30	20	6.26	30
3089	7.87	120.09	328	212.00	149.6	47	26	4.00	30
3090	7.94	222.99	573	238.00	275.3	25	24	7.43	30
3091	8.20	199.65	420	276.00	238.7	30	22	6.66	30
3092.	8.98	324.37	616	286.00	354.1	22	25	10.81	30
3093	8.02	205.79	491	248.00	251.6	28	23	6.86	30
3094	9.11	355.25	695	296.00	382.3	21	25	11.84	30
3095	9.14	349.11	664	290.00	374.5	21	26	11.64	30
3096	8.03	267.20	610	262.00	326.2	22	22	8.91	30
3097	7.84	143.79	370	226.00	179.8	39	24	4.79	30
3098	9.88	554.25	866	358.00	550.0	16	25	18.48	30
3099	8.43	245.30	641	224.00	285.3	26	29	8.18	30
3100	6.68	104.75	393	174.00	153.7	39	23	3.49	30

APPENDIX C

ANALYSIS OF TEST RESULTS OF FUSES

STATISTICAL SUMMARIES OF FILES OF DATA FOR PHASES 1.1 AND 1.2

DATA IDENTIFICATION

Variable No.	Symbol	Identity
1		Item number
2	R_0	Initial resistance (ohms)
3	V_m	Maximum voltage (millivolts) in histograms (volts)
4	τ	Thermal time constant (seconds)
5	S	Initial slope (volts/sec)
6	θ	Temperature rise (^oC)
7	γ	Heat loss (watts)
8	C_p	Heat capacity of system (watts-seconds)
9	ΔR	Resistance change (ohms)

```
                ***** HISTOGRAM FOR VARIABLE:   2   *****   PHASE 1.1

40.00 +
      I
      I
      I
      I
30.00 +
      I
      I
      I                   IXXXXXI
      I                   IXXXXXI     IXXXXXI
20.00 +             IXXXXXIXXXXXI     IXXXXXI
      I             IXXXXXIXXXXXI     IXXXXXI
      I             IXXXXXIXXXXXIXXXXXIXXXXXI
      I             IXXXXXIXXXXXIXXXXXIXXXXXI
      I             IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 +       IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+-----+
        ^  5  ^ 10  ^ 19  ^ 23  ^ 16  ^ 21  ^  4  ^  2  ^
        ^     ^     ^     ^     ^     ^     ^     ^     ^
        ^  7.14     ^  8.14     ^  9.14     ^  10.1     ^
      6.64        7.64        8.64        9.64        10.6
```

***** HISTOGRAM FOR VARIABLE: 3   ***** PHASE 1.1

```
40.00 +
      I
      I
      I
      I
30.00 +             IXXXXXI
      I             IXXXXXI
      I       IXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
20.00 +       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 + IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  15 ^  26 ^  30 ^  23 ^   4 ^   2 ^
        ^     ^     ^     ^     ^     ^     ^
        ^   .147E-01^   .246E-01^   .346E-01^
       .965E-02    .196E-01    .296E-01    .396E-01
```

***** HISTOGRAM FOR VARIABLE: 4   ***** PHASE 1.1

```
40.00 +
      I
      I
      I
      I
30.00 +                   IXXXXXI
      I                   IXXXXXI
      I                   IXXXXXI
      I                   IXXXXXI
      I                   IXXXXXI
20.00 +             IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 +       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^   4 ^  17 ^  20 ^  31 ^  20 ^   8 ^
        ^     ^     ^     ^     ^     ^     ^
        ^   .233E-03^   .333E-03^   .433E-03^
       .183E-03    .283E-03    .383E-03    .483E-03
```

```
                 ***** HISTOGRAM FOR VARIABLE:   5   *****    PHASE 1.1

40.00 +
      I
      I
      I
      I
30.00 +
      I                    IXXXXXI
      I        IXXXXXI     IXXXXXI
      I        IXXXXXIXXXXXIXXXXXI
      I        IXXXXXIXXXXXIXXXXXI
20.00 +        IXXXXXIXXXXXIXXXXXI
      I        IXXXXXIXXXXXIXXXXXI
      I        IXXXXXIXXXXXIXXXXXI
      I        IXXXXXIXXXXXIXXXXXI
      I        IXXXXXIXXXXXIXXXXXI
10.00 +  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+-----+
        ^  9  ^ 25  ^ 23  ^ 27  ^ 10  ^  3  ^  2  ^  1  ^
        ^     ^     ^     ^     ^     ^     ^     ^     ^
        ^   43.0    ^   63.0    ^   83.0    ^   103.    ^
      33.0        53.0        73.0        93.0        113.
```

```
                 ***** HISTOGRAM FOR VARIABLE:   6   *****    PHASE 1.1

40.00 +
      I
      I
      I
      I
30.00 +
      I                    IXXXXXI
      I                    IXXXXXI
      I                    IXXXXXI
      I              IXXXXXIXXXXXIXXXXXI
20.00 +              IXXXXXIXXXXXIXXXXXI
      I              IXXXXXIXXXXXIXXXXXI
      I              IXXXXXIXXXXXIXXXXXI
      I              IXXXXXIXXXXXIXXXXXI
      I              IXXXXXIXXXXXIXXXXXI
10.00 +        IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I  IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+
        ^  7  ^ 10  ^ 22  ^ 27  ^ 21  ^  9  ^  4  ^
        ^     ^     ^     ^     ^     ^     ^     ^
        ^   24.7    ^   34.7    ^   44.7    ^   54.7
      19.7        29.7        39.7        49.7
```

***** HISTOGRAM FOR VARIABLE: 7   ***** PHASE 1.1

```
50.00 +
      I
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
37.50 +       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
25.00 +       IXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
12.50 + IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  22 ^  46 ^  18 ^   8 ^   3 ^   3 ^
        ^     ^     ^     ^     ^     ^     ^
        ^   .792E-04^   .119E-03^   .159E-03^
       .592E-04   .992E-04   .139E-03   .179E-03
```

***** HISTOGRAM FOR VARIABLE: 8   ***** PHASE 1.1

```
80.00 +
      I
      I
      I
      I       IXXXXXI
60.00 +       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
40.00 +       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
20.00 + IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+
        ^  26 ^  65 ^   8 ^   0 ^   1 ^
        ^     ^     ^     ^     ^     ^
        ^   .310E-07^   .510E-07^   .710E-07
       .210E-07   .410E-07   .610E-07
```

***** HISTOGRAM FOR VARIABLE: 9   ***** PHASE 1.1

```
40.00 +
      I
      I
      I             IXXXXXI
      I             IXXXXXI
30.00 +             IXXXXXI
      I             IXXXXXI
      I             IXXXXXI
      I             IXXXXXI
      I             IXXXXXI
20.00 +             IXXXXXIXXXXXI
      I             IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 + IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+
        ^   9 ^  16 ^  33 ^  19 ^  17 ^   4 ^   2 ^
        ^     ^     ^     ^     ^     ^     ^     ^
        ^   .683    ^    1.08     ^    1.48     ^    1.88
         .483        .883        1.28        1.68
```

THERE ARE 9 VARIABLES AND 100 OBSERVATIONS PHASE 1.1

VAR.	MEANS	STD.DEV.	VARIANCE
1	1050.500	29.01157	841.6711
2	8.488140	0.8298198	0.6886008
3	0.2119100E-01	0.5499009E-02	0.3023910E-04
4	0.3434542E-03	0.6538760E-04	0.4275538E-08
5	59.66000	13.84855	191.7822
6	36.44643	7.477817	55.91775
7	0.9697495E-04	0.2221124E-04	0.4933390E-09
8	0.3389000E-07	0.5747011E-08	0.3302814E-16
9	1.059550	0.2749506	0.7559784E-01

***** CORRELATION MATRIX ***** PHASE 1.1

VAR.	1	2	3	4	5	6	7	8	9
1	1.0000								
2	-0.1561	1.0000							
3	-0.0807	0.6638	1.0000						
4	-0.0496	0.0838	0.5270	1.0000					
5	-0.0486	0.7226	0.7261	-0.1817	1.0000				
6	-0.0277	0.3695	0.9366	0.6257	0.5689	1.0000			
7	-0.0842	0.1158	-0.6346	-0.5969	-0.2394	-0.8462	1.0000		
8	-0.0836	0.1745	-0.2558	0.3206	-0.5248	-0.3970	0.5366	1.0000	
9	-0.0807	0.6638	1.0000	0.5270	0.7261	0.9366	-0.6346	-0.2558	1.0000

***** HISTOGRAM FOR VARIABLE: 2   ***** PHASE 1.2

```
40.00 +
      I
      I
      I
      I
30.00 +
      I
      I
      I                   IXXXXXI
      I             IXXXXXIXXXXXI
20.00 +             IXXXXXIXXXXXI
      I             IXXXXXIXXXXXIXXXXXI
      I             IXXXXXIXXXXXIXXXXXI
      I             IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 +       IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+-----+
        ^  24 ^  37 ^  67 ^  74 ^  51 ^  29 ^  15 ^   3 ^
        ^     ^     ^     ^     ^     ^     ^     ^     ^
        ^   7.10    ^   8.10    ^   9.10    ^   10.1    ^
       6.60        7.60        8.60        9.60        10.6
```

***** HISTOGRAM FOR VARIABLE: 3   ***** PHASE 1.2

```
50.00 +       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
37.50 +       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
25.00 +       IXXXXXI
      I       IXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
12.50 + IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  59 ^ 150 ^  69 ^  18 ^   3 ^   1 ^
        ^     ^     ^     ^     ^     ^     ^
        ^   .417E-01^   .817E-01^   .122    ^
      .217E-01    .617E-01    .102        .142
```

```
***** HISTOGRAM FOR VARIABLE:   4   *****  PHASE 1.2

80.00 +
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
60.00 + IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
40.00 + IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXIXXXXXI
20.00 + IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+-----+
        ^ 232 ^  67 ^   0 ^   0 ^   0 ^   0 ^   0 ^   1 ^
        ^     ^     ^     ^     ^     ^     ^     ^     ^
        ^  .444E-03^  .944E-03^  .144E-02^  .194E-02^
      .194E-03  .694E-03   .119E-02   .169E-02   .219E-02


***** HISTOGRAM FOR VARIABLE:   5   *****  PHASE 1.2

40.00 +
      I
      I
      I
      I
30.00 +             IXXXXXI
      I             IXXXXXI
      I             IXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
20.00 +       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXI
10.00 +       IXXXXXIXXXXXIXXXXXIXXXXXI
      I       IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+-----+
        ^  16 ^  70 ^  88 ^  80 ^  28 ^  12 ^   5 ^   1 ^
        ^     ^     ^     ^     ^     ^     ^     ^     ^
        ^   110.    ^   160.    ^   210.    ^   260.    ^
       85.0      135.       185.       235.        285.
```

```
          ***** HISTOGRAM FOR VARIABLE:   6   ***** PHASE 1.2

50.00 +
      I
      I
      I            IXXXXXI
      I            IXXXXXI
37.50 +            IXXXXXI
      I            IXXXXXI
      I      IXXXXXIXXXXXI
      I      IXXXXXIXXXXXI
      I      IXXXXXIXXXXXI
25.00 +      IXXXXXIXXXXXI
      I      IXXXXXIXXXXXI
      I      IXXXXXIXXXXXI
      I      IXXXXXIXXXXXIXXXXXI
      I      IXXXXXIXXXXXIXXXXXI
12.50 +      IXXXXXIXXXXXIXXXXXI
      I      IXXXXXIXXXXXIXXXXXI
      I      IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  15 ^  98 ^ 124 ^  51 ^  10 ^   2 ^
        ^     ^     ^     ^     ^     ^     ^
        ^   52.0    ^   92.0    ^   132.    ^
       32.0        72.0        112.        152.
```

```
          ***** HISTOGRAM FOR VARIABLE:   7   ***** PHASE 1.2

50.00 +
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
      I       IXXXXXI
37.50 + IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
25.00 + IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
12.50 + IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+
        ^ 113 ^ 145 ^  36 ^   4 ^   1 ^   0 ^   1 ^
        ^     ^     ^     ^     ^     ^     ^     ^
        ^   .625E-04^   .102E-03^   .142E-03^   .182E-03
       .425E-04    .825E-04    .122E-03    .162E-03
```

***** HISTOGRAM FOR VARIABLE: 8   *****   PHASE 1.2

```
 80.00 +
       I
       I
       I
       I       IXXXXXI
 60.00 +       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
 40.00 +       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
       I       IXXXXXIXXXXXI
 20.00 +       IXXXXXIXXXXXI
       I       IXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       --+-----+-----+-----+-----+-----+-----+-----+
         ^  32 ^ 196 ^  68 ^   1 ^   1 ^   1 ^   1 ^
         ^     ^     ^     ^     ^     ^     ^     ^
         ^   .210E-07^   .310E-07^   .410E-07^   .510E-07
^L     .160E-07   .260E-07    .360E-07    .460E-07
```

***** HISTOGRAM FOR VARIABLE: 9   *****   PHASE 1.2

```
 60.00 +
       I
       I
       I       IXXXXXI
       I       IXXXXXI
 45.00 +       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
       I       IXXXXXI
       I IXXXXXIXXXXXI
 30.00 + IXXXXXIXXXXXI
       I IXXXXXIXXXXXI
       I IXXXXXIXXXXXI
       I IXXXXXIXXXXXI
       I IXXXXXIXXXXXI
 15.00 + IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXI
       --+-----+-----+-----+-----+-----+
         ^ 101 ^ 153 ^  41 ^   4 ^   1 ^
         ^     ^     ^     ^     ^     ^
         ^   1.87    ^   3.87    ^   5.87
       .866       2.87       4.87
```

THERE ARE 9 VARIABLES AND 300 OBSERVATIONS PHASE 1.2

VAR.	MEANS	STD.DEV.	VARIANCE
1	2147.167	89.15654	7948.888
2	8.260300	0.7824506	0.6122290
3	0.5578924E-01	0.1644404E-01	0.2704065E-03
4	0.3972572E-03	0.1243652E-03	0.1546669E-07
5	154.8833	31.27101	977.8761
6	78.48135	17.50079	306.2777
7	0.6842112E-04	0.1432680E-04	0.2052573E-09
8	0.2386000E-07	0.3437030E-08	0.1181317E-16
9	2.231570	0.6577612	0.4326498

***** CORRELATION MATRIX ***** PHASE 1.2

VAR.							
1	1.0000						
2	-0.0591	1.0000					
3	-0.0733	0.7737	1.0000				
4	0.7490	0.1752	0.3997	1.0000			
5	-0.1286	0.7662	0.7903	0.0371	1.0000		
6	-0.0760	0.5909	0.9642	0.4382	0.7079	1.0000	
7	0.0470	-0.1407	-0.6809	-0.4038	-0.4381	-0.8287	1.0000
	1	2	3	4	5	6	7

APPENDIX D

DESTRUCTIVE TEST RESULTS ON PREVIOUSLY NDT'd FUSES

Destructive Testing 1.6

DATA FILE ALLCB1.PAT

A lot of 50 items from 1.1 where subjected to a current pulse that was nearly certain to open the wire. The waveforms were computed for the energy input, break time and average current.

THERE ARE 16 VARIABLES AND 50 OBSERVATIONS

VAR.	MEANS	STD.DEV.	VARIANCE
1	1030.680	16.61983	276.2188
2	8.790080	0.6091740	0.3710930
3	0.2275400E-01	0.5050508E-02	0.2550763E-04
4	0.3542994E-03	0.6608724E-04	0.4367523E-08
5	62.40000	11.85456	140.5306
6	38.00746	7.475132	55.87760
7	0.9664790E-04	0.2392419E-04	0.5723670E-09
8	0.3448000E-07	0.4970273E-08	0.2470361E-16
9	1.137700	0.2525255	0.6376911E-01
10	0.2000000E-01	0.6975446E-05	0.4865685E-10
11	5030.680	16.62769	276.4800
12	8.634346	0.6149284	0.3781370
13	0.1972382E-03	0.8111669E-04	0.6579917E-08
14	0.2885000E-02	0.1533573E-02	0.2351846E-05
15	0.4006995E-01	0.5000719E-03	0.2500719E-06
16	42.00000	0.0000000	0.0000000

IDENTITY OF NUMBER CODE ABOVE

Variable	Meaning
1	Test Number
2	Initial Resistance
3	Max Voltage
4	Thermal Time Constant
5	Initial Slope
6	Temperature Rise
7	Heat Loss
8	Heat Capacity
9	Resistance Change
10	Pulse Current (Nominal)
11	Test Number (Energy Test)
12	Resistance
13	Energy
14	Time to Break
15	Average Current
16	Nominal Current

***** CORRELATION MATRIX *****

VAR.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.0000															
2	-0.0729	1.0000														
3	0.0192	0.4184	1.0000													
4	0.1540	-0.1868	0.5713	1.0000												
5	-0.1736	0.6568	0.6275	-0.2649	1.0000											
6	0.0492	0.1186	0.9499	0.6905	0.4630	1.0000										
7	-0.0841	0.2577	-0.7399	-0.7459	-0.1757	-0.8976	1.0000									
8	0.1294	0.1167	-0.3985	0.1809	-0.6580	-0.4805	0.4736	1.0000								
9	0.0192	0.4184	1.0000	0.5713	0.6275	0.9499	-0.7399	-0.3985	1.0000							
10	-0.0103	-0.0048	-0.0012	-0.0016	-0.0011	-0.0011	-0.0011	-0.0013	-0.0010	1.0000						
11	1.0003	-0.0730	0.0193	0.1539	-0.1735	0.0492	-0.0841	0.1292	0.0193	-0.0687	1.0000					
12	-0.0824	0.9639	0.4411	-0.2103	0.7062	0.1548	0.2197	0.0067	0.4411	-0.0025	-0.0823	1.0000				
13	0.0788	-0.6566	-0.5892	-0.0301	-0.6616	-0.4371	0.1633	0.2636	-0.5892	-0.0004	0.0788	-0.6732	1.0000			
14	0.0411	-0.6945	-0.5799	-0.0514	-0.6347	-0.4168	0.1358	0.1934	-0.5799	-0.0004	0.0410	-0.7083	0.9859	1.0000		
15	-0.2766	-0.2722	-0.1185	0.2051	-0.3218	-0.0270	-0.0528	0.1247	-0.1185	-0.0174	-0.2767	-0.2484	0.1248	0.1044	1.0000	
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Table D-1 Pretest and Destructive Test Data on Fuses (20 milliampere pretest]

1TEST NO.	INITIAL RESIST.	MAXIMUM VOLTAGE	THERMAL TIME-CON	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESIST CHANGE	PULSE CURRENT	OPEN ENERGY	OPEN TIME	AVERAGE CURRENT
	ohms	mV	usec	V/sec	deg C	uW/C′	nJ/C′	ohms	ma	uJ	usec	ma
1004	8.97	20.50	264	73	33.6	107	30	1.03	20	134	1790	40.4
1005	9.10	20.40	289	66	33.0	110	34	1.02	20	195	2680	41.2
1006	9.15	18.60	337	54	29.9	123	42	0.93	20	167	2240	40.1
1007	7.16	16.30	334	47	33.5	86	30	0.81	20	483	9420	40.2
1008	9.37	14.05	198	65	22.1	170	37	0.70	20	136	1930	40.6
1009	8.59	25.40	466	53	43.5	79	38	1.27	20	176	2390	41.4
1010	9.35	14.10	183	71	22.2	169	33	0.70	20	148	2010	40.0
1011	8.51	19.85	259	73	34.3	99	27	0.99	20	162	2480	40.2
1012	8.97	25.50	303	79	41.8	86	28	1.28	20	91	1310	39.0
1013	9.20	27.05	482	54	43.3	85	43	1.35	20	183	2420	40.9
1014	9.00	30.05	412	71	49.1	73	31	1.50	20	151	1940	40.7
1015	9.29	27.85	385	70	44.1	84	34	1.39	20	138	1820	39.5
1016	9.62	30.80	334	89	47.1	82	28	1.54	20	129	1550	40.0
1017	8.13	19.05	359	50	34.5	94	36	0.95	20	258	3790	40.0
1018	7.77	18.40	456	38	34.8	89	43	0.92	20	302	4690	40.5
1019	8.57	21.15	407	52	36.3	94	38	1.06	20	292	4380	40.0
1020	7.93	22.10	326	72	41.0	77	24	1.11	20	344	5380	40.1
1021	9.36	24.65	336	70	38.7	97	34	1.23	20	163	2070	40.1
1023	10.00	36.00	367	95	52.9	76	29	1.80	20	84	1040	39.5
1024	8.98	18.35	362	49	30.1	120	45	0.92	20	291	4570	40.0
1025	7.91	17.30	338	48	32.2	98	35	0.86	20	334	5460	40.3
1027	8.32	26.70	422	64	47.2	71	29	1.33	20	171	2320	40.1
1028	9.02	29.10	417	68	47.4	76	33	1.45	20	134	1710	39.9
1029	8.78	27.25	356	74	45.6	77	28	1.36	20	131	1780	39.8
1030	8.49	23.50	363	61	40.7	83	32	1.17	20	149	2050	40.3
1031	9.14	26.05	375	67	41.9	87	34	1.30	20	162	2100	40.4
1032	8.67	26.25	424	60	44.5	78	34	1.31	20	176	2480	39.6
1033	8.67	24.35	347	66	41.3	84	31	1.22	20	120	1700	40.5
1034	9.43	32.85	459	70	51.2	74	35	1.64	20	127	1620	40.6
1035	8.92	22.15	401	53	36.5	98	41	1.11	20	165	2350	39.6
1037	8.58	14.15	259	51	24.3	142	39	0.71	20	202	3170	39.9
1038	9.56	18.85	288	62	29.0	132	40	0.94	20	262	3540	39.3
1039	10.27	26.40	284	88	37.8	109	33	1.32	20	107	1300	39.1
1040	8.05	18.75	300	59	34.3	94	30	0.94	20	247	3920	40.3
1041	8.08	21.10	413	49	38.4	84	36	1.06	20	232	3570	39.7
1043	8.70	18.15	328	54	30.7	113	38	0.91	20	179	2480	40.0
1044	8.99	23.10	289	75	37.8	95	29	1.16	20	175	2390	39.3
1045	8.81	20.45	359	55	34.1	103	38	1.02	20	261	3820	40.3

Table D-1 cont.

1TEST NO.	INITIAL RESIST.	MAXIMUM VOLTAGE	THERMAL TIME-CON	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESIST CHANGE	PULSE CURRENT	OPEN ENERGY	OPEN TIME	AVERAGE CURRENT
1046	9.58	19.45	325	58	29.9	128	43	0.97	20	163	2070	40.2
1047	7.64	21.45	367	56	41.3	74	28	1.07	20	230	3680	40.3
1048	9.42	31.90	427	74	49.8	76	33	1.59	20	128	1730	38.9
1049	8.20	20.95	409	49	37.6	87	37	1.05	20	224	3410	39.9
1050	8.68	21.40	321	63	36.3	96	33	1.07	20	159	2320	39.5
1051	8.59	23.45	434	52	40.1	86	39	1.17	20	177	2560	40.4
1053	9.01	26.05	364	69	42.5	85	32	1.30	20	131	1760	39.8
1054	8.31	23.15	413	54	41.0	81	35	1.16	20	222	3290	40.4
1056	9.27	22.30	343	63	35.4	105	37	1.11	20	231	2940	39.9
1058	8.47	26.15	398	63	45.4	75	31	1.31	20	182	2480	40.6
1059	8.40	22.25	367	59	39.0	86	33	1.11	20	218	3270	40.3
1060	8.52	12.60	265	45	21.7	157	44	0.63	20	436	7080	39.8
	ohms	mV	usec	V/sec	deg C	uW/C´	nJ/C´	ohms	ma	uJ	usec	ma

THERE ARE 13 VARIABLES AND 50 OBSERVATIONS

VAR.	MEANS	STD.DEV.	VARIANCE
1	1030.680	16.61983	276.2188
2	8.790080	0.6091740	0.3710930
3	0.2275400E-01	0.5050508E-02	0.2550763E-04
4	0.3542994E-03	0.6608724E-04	0.4367523E-08
5	62.40000	11.85456	140.5306
6	38.00746	7.475132	55.87760
7	0.9664790E-04	0.2392419E-04	0.5723670E-09
8	0.3448000E-07	0.4970273E-08	0.2470361E-16
9	1.137700	0.2525255	0.6376911E-01
10	0.2000000E-01	0.6975446E-05	0.4865685E-10
11	0.1972382E-03	0.8111669E-04	0.6579917E-08
12	0.2885000E-02	0.1533573E-02	0.2351846E-05
13	0.4006995E-01	0.5000[illegible]E-03	0.2500[illegible]E-01

VAR.	MEDIAN	MODE	MAXIMUM	MINIMUM
1	1030.500	1004.000 *	1060.000	1004.000
2	8.795000	8.590000 *	10.27000	7.160000
3	0.2220000E-01	0.2605000E-01	0.3600000E-01	0.1260000E-01
4	0.3594100E-03	0.2885400E-03	0.4821000E-03	0.1832600E-03
5	62.50000	54.00000	95.00000	38.00000
6	38.10279	21.74814 *	52.94118	21.74814
7	0.8726400E-04	0.7051900E-04*	0.1699700E-03	0.7051900E-04
8	0.3400000E-07	0.3300000E-07	0.4500000E-07	0.2400000E-07
9	1.110000	1.302500	1.800000	0.6300000
10	0.2000000E-01	0.2000000E-01	0.2000000E-01	0.2000000E-01
11	0.1753300E-03	0.8421000E-04*	0.4832400E-03	0.8421000E-04
12	0.2405000E-02	0.2480000E-02	0.9420000E-02	0.1040000E-02
13	0.4012100E-01	0.3887283E-01*	0.4136293E-01	0.3887283E-01

* More than 1 mode exists -- only the first is shown.

Table D-1-1 Data Summary from Table D-1 Data

Table D-2 Pretest and Destructive Test Data on Fuses (25 milliapere pretest)

TEST NO.	INITIAL RESIST.	MAXIMUM VOLTAGE	THERMAL TIME-CON	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESIST CHANGE	PULSE CURRENT	OPEN ENERGY	OPEN TIME	AVERAGE CURRENT
	ohms	mV	usec	V/sec	deg C	uW/C'	nJ/C'	ohms	ma	uJ	usec	ma
2001	7.76	43.05	281	183	65.3	74	17	1.72	25	272	3850	44.0
2002	8.32	56.90	341	188	80.5	65	20	2.28	25	173	2210	43.7
2004	8.49	59.00	351	211	81.8	65	18	2.36	25	156	1990	43.1
2005	8.16	46.30	331	159	66.8	76	22	1.85	25	552	7950	42.8
2007	7.77	53.30	371	169	80.7	60	19	2.13	25	171	2390	42.3
2008	8.06	61.40	501	140	89.6	56	25	2.46	25	228	3100	42.6
2009	8.13	53.25	394	144	77.1	66	24	2.13	25	248	3410	42.6
2011	8.65	61.60	420	158	83.8	65	25	2.46	25	182	2330	42.7
2012	8.76	61.10	367	174	82.1	67	23	2.44	25	136	1850	42.0
2014	9.05	53.70	352	171	69.8	81	25	2.15	25	199	2790	42.6
2016	8.20	54.40	392	149	78.0	66	24	2.18	25	177	2430	42.7
2017	7.03	38.35	364	112	64.2	68	23	1.53	25	380	6550	41.8
2018	7.51	33.55	299	114	52.6	89	26	1.34	25	1649	29980	42.7
2019	8.54	62.10	376	178	85.5	62	22	2.48	25	136	1780	42.7
2020	8.25	41.15	267	156	58.7	88	23	1.65	25	242	3020	42.5
2021	7.99	61.20	485	147	90.1	55	23	2.45	25	212	2820	42.6
2022	7.58	36.30	309	121	56.3	84	25	1.45	25	504	8060	42.8
2023	7.71	51.00	370	143	77.8	62	22	2.04	25	258	3660	43.0
2024	7.86	36.05	343	110	54.0	91	30	1.44	25	1354	24180	42.9
2025	7.36	41.90	365	130	67.0	69	22	1.68	25	345	5480	43.0
2026	8.07	52.05	365	148	75.9	66	23	2.08	25	1537	25080	43.3
2027	9.18	74.05	411	188	94.9	60	24	2.96	25	157	1760	43.2
2028	8.14	40.40	522	113	58.4	87	31	1.62	25	2464	44350	42.0
2029	7.29	39.45	317	129	63.7	72	22	1.58	25	344	5300	43.4
2030	8.28	66.75	561	140	94.8	55	26	2.67	25	245	3180	42.7
2031	8.73	62.95	417	165	84.8	64	25	2.52	25	197	2400	43.0
2032	9.28	71.45	398	189	90.6	64	24	2.86	25	121	1460	42.9
2033	7.23	44.80	439	114	72.9	62	24	1.79	25	1623	28300	43.4
2034	8.31	53.90	373	154	76.3	68	24	2.16	25	202	2980	42.2
2035	6.96	35.15	370	102	59.4	73	25	1.41	25	2910	59750	42.8
2036	8.04	44.95	323	151	65.8	76	23	1.80	25	163	2400	41.3
2037	9.16	61.50	365	176	79.0	72	25	2.46	25	160	1920	41.8
2039	9.53	89.75	544	191	110.8	54	25	3.59	25	157	1820	42.1

Table D-2 cont.

2041	9.21	60.20	373	176	76.9	75	26	2.41	25	220	2680	40.7
2042	7.02	41.10	410	111	68.9	64	24	1.64	25	2443	49750	41.3
2043	9.01	54.95	422	140	71.8	78	31	2.20	25	188	2600	40.1
2044	9.14	70.50	466	168	90.7	63	26	2.82	25	151	1940	40.5
2045	7.76	50.65	433	137	76.8	63	23	2.03	25	251	3920	41.1
2046	7.98	70.50	466	162	103.9	48	21	2.82	25	178	2500	40.9
2047	7.42	40.35	319	136	64.0	72	22	1.61	25	3518	67250	41.8
2048	7.54	52.80	308	181	82.4	57	17	2.11	25	238	3600	41.1
2049	8.41	83.85	549	184	117.3	45	20	3.35	25	189	2540	40.9
2050	7.27	45.40	309	149	73.5	62	19	1.82	25	272	4560	41.0
2051	7.74	50.90	317	177	77.4	63	18	2.04	25	339	5380	41.0
2052	6.92	42.75	316	149	72.7	60	17	1.71	25	1078	21540	41.3
2053	8.22	47.85	279	175	68.5	75	21	1.91	25	271	4060	41.0
2054	9.82	92.70	460	200	111.1	55	26	3.71	25	137	1520	41.0
2055	8.38	87.85	427	231	123.3	42	16	3.51	25	97	1320	41.6
2057	8.17	46.75	271	175	67.3	76	20	1.87	25	1454	27120	40.8
2056	8.28	54.55	342	169	77.5	67	22	2.18	25	178	2620	40.6
1TEST NO.	INITIAL RESIST.	MAXIMUM VOLTAGE	THERMAL TIME-CON	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESIST CHANGE	PULSE CURRENT	OPEN ENERGY	OPEN TIME	AVERAGE CURRENT
	ohms	mV	usec	V/sec	deg C	uW/C´	nJ/C´	ohms	ma	uJ	usec	ma
2059	8.59	57.85	371	163	79.2	68	24	2.31	25	174	2380	40.0
2061	8.05	56.55	407	164	82.6	61	21	2.26	25	213	2960	40.7
2062	9.33	79.60	337	253	100.4	58	18	3.18	25	104	1260	39.8

THERE ARE 13 VARIABLES AND 53 OBSERVATIONS

VAR.	MEANS.	STD.DEV.	VARIANCE
1	2032.302	17.41361	303.2337
2	8.181887	0.7038335	0.4953815
3	0.5529057E-01	0.1433947E-01	0.2056203E-03
4	0.3823862E-03	0.7189210E-04	0.5168474E-08
5	158.8113	30.68453	941.5406
6	78.77127	15.65022	244.9294
7	0.6671206E-04	0.1058105E-04	0.1119585E-09
8	0.2284906E-07	0.3313122E-08	0.1097678E-16
9	2.211623	0.5735787	0.3289926
10	0.2500000E-01	0.2325254E-05	0.5406807E-11
11	0.5575157E-03	0.7809820E-03	0.6099329E-06
12	0.9660944E-02	0.1533684E-01	0.2352185E-03
13	0.4200504E-01	0.1049264E-02	0.1100956E-05

VAR.	MEDIAN	MODE	MAXIMUM	MINIMUM
1	2032.000	2001.000 *	2062.000	2001.000
2	8.160000	7.760000 *	9.820000	6.920000
3	0.5370000E-01	0.7050000E-01	0.9270000E-01	0.3355000E-01
4	0.3700500E-03	0.2673500E-03*	0.5608500E-03	0.2673500E-03
5	159.0000	140.0000 *	253.0000	102.0000
6	77.36738	52.55737 *	123.3329	52.55737
7	0.6490300E-04	0.4246600E-04*	0.9104100E-04	0.4246600E-04
8	0.2300000E-07	0.2400000E-07*	0.3100000E-07	0.1600000E-07
9	2.148000	2.820000	3.708000	1.342000
10	0.2500000E-01	0.2500000E-01	0.2500000E-01	0.2500000E-01
11	0.2196700E-03	0.9731000E-04*	0.3517550E-02	0.9731000E-04
12	0.2980000E-02	0.2400000E-02	0.6725000E-01	0.1260000E-02
13	0.4221352E-01	0.3975897E-01*	0.4404185E-01	0.3975897E-01

* MORE THAN 1 MODE EXISTS - ONLY THE FIRST IS SHOWN

Table D-2-1 Data Summary from Table D-2 Data

Table D-3 Pretest and Destructive Test Data on Fuses (30 milliampere pretest)

1TEST NO.	INITIAL RESIST.	MAXIMUM VOLTAGE	THERMAL TIME-CON	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESIST CHANGE	PULSE CURRENT	OPEN ENERGY	OPEN TIME	AVERAGE CURRENT
	ohms	mV	usec	V/sec	deg C	uW/C'	nJ/C'	ohms	ma	uJ	usec	ma
3001	7.70	118.45	551	231	150.8	46	24	3.95	30	328	4900	41.8
3002	8.54	134.80	618	250	154.8	50	27	4.49	30	206	2800	42.2
3003	8.61	169.20	640	302	192.7	40	23	5.64	30	152	1900	41.0
3004	7.62	110.90	569	214	142.7	48	25	3.70	30	232	3750	41.1
3005	7.68	102.70	500	224	131.1	53	24	3.42	30	307	4700	41.6
3006	6.90	82.20	364	232	116.8	53	19	2.74	30	811	15550	42.2
3007	8.46	122.20	405	290	141.6	54	23	4.07	30	166	2250	41.2
3008	9.07	259.00	792	392	280.0	29	19	8.63	30	117	1450	39.4
3009	9.67	140.80	620	348	142.7	61	25	4.69	30	206	2750	41.6
3011	7.55	107.80	586	208	140.0	49	25	3.59	30	260	4000	41.7
3013	7.57	96.70	497	212	125.2	54	25	3.22	30	428	7200	41.4
3014	6.78	70.20	390	188	101.5	60	22	2.34	30	1512	31200	41.7
3015	7.94	110.40	537	226	136.3	52	26	3.68	30	435	9550	42.0
3016	7.48	108.60	432	258	142.3	47	20	3.62	30	263	6000	42.1
3018	9.78	186.30	471	394	186.8	47	22	6.21	30	119	2350	40.9
3019	8.43	139.40	798	256	162.1	47	25	4.65	30	268	5250	41.9
3020	6.80	110.30	451	262	159.0	38	16	3.68	30	335	7550	42.3
3022	7.60	96.10	445	238	124.0	55	22	3.20	30	698	11800	41.9
3023	6.68	103.30	415	256	151.6	40	16	3.44	30	139	3000	41.8
3024	9.69	242.90	786	350	245.8	35	25	8.10	30	126	1850	41.5
3025	8.36	177.70	641	296	208.4	36	22	5.92	30	150	2350	41.4
3026	7.97	151.00	617	266	185.7	39	22	5.03	30	207	2850	41.5
3027	8.95	152.60	665	248	167.2	48	30	5.09	30	256	4150	42.0
3028	9.16	272.40	883	334	291.5	28	23	9.08	30	115	1750	41.2
3029	9.06	206.90	773	302	223.9	36	25	6.90	30	155	2300	41.7
3030	8.73	129.10	466	318	145.0	54	22	4.30	30	132	2650	41.9
3031	7.63	117.80	471	262	151.4	45	20	3.93	30	1216	45650	42.4
3032	7.83	132.50	623	238	165.9	42	24	4.42	30	202	4300	42.2
3033	7.54	95.40	457	246	124.0	55	21	3.18	30	718	16250	42.0
3034	7.99	108.70	421	272	133.4	54	22	3.62	30	131	2400	41.5

Table D-3 cont.

TEST NO.	INITIAL RESIST.	MAXIMUM VOLTAGE	THERMAL TIME-CON	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESIST CHANGE	PULSE CURRENT	OPEN ENERGY	OPEN TIME	AVERAGE CURRENT
3035	7.73	139.20	670	228	176.5	39	24	4.64	30	255	4500	42.3
3036	8.27	107.70	445	270	127.7	58	23	3.59	30	284	4500	42.2
3037	7.30	71.00	309	230	95.4	69	21	2.37	30	951	20550	42.2
3038	8.32	151.20	552	290	178.2	42	22	5.04	30	129	2100	41.3
3039	7.76	125.60	518	264	158.7	44	21	4.19	30	168	3100	41.8
3040	7.06	84.00	351	242	116.6	54	19	2.80	30	2022	60800	42.3
3041	8.32	128.60	564	244	151.5	49	26	4.29	30	140	2650	41.1
3043	6.94	106.20	588	204	150.0	42	22	3.54	30	941	22700	42.2
3045	7.77	135.60	489	296	171.1	41	19	4.52	30	153	2900	41.8
3046	8.67	177.50	650	296	200.7	39	23	5.92	30	144	2300	41.5
3047	8.82	192.40	713	296	213.9	37	24	6.41	30	160	2400	41.6
3048	7.88	106.30	436	256	132.3	54	22	3.54	30	456	9250	42.3
3049	8.98	250.30	766	360	273.3	30	21	8.34	30	117	1700	41.1
3050	9.65	146.80	536	300	149.1	58	28	4.89	30	241	3750	42.0
3051	8.94	244.10	829	326	267.7	30	23	8.14	30	135	1950	41.3
3052	8.93	205.40	761	320	225.5	36	23	6.85	30	218	2650	41.1
3053	8.56	118.30	516	268	135.5	57	25	3.94	30	223	3800	41.5
3054	9.54	225.20	670	350	231.4	37	24	7.51	30	278	2800	41.2
3055	6.78	94.30	470	214	136.4	45	20	3.14	30	2828	57400	42.7
3056	9.14	113.70	326	348	122.0	67	22	3.79	30	100	2050	42.1
	ohms	mV	usec	V/sec	deg C	uW/C'	nJ/C'	ohms	ma	uJ	usec	ma

THERE ARE 13 VARIABLES AND 50 OBSERVATIONS

VAR.	MEANS	STD.DEV.	VARIANCE
1	3029.000	16.53000	273.2408
2	8.182600	0.8547796	0.7306481
3	0.1415950	0.5127790E-01	0.2629423E-02
4	0.5608434E-03	0.1418728E-03	0.2012789E-07
5	274.3000	49.84066	2484.091
6	166.7509	47.14913	2223.040
7	0.4651548E-04	0.9680136E-05	0.9370503E-10
8	0.2272000E-07	0.2703282E-08	0.7307733E-17
9	4.719833	1.709263	2.921579
10	0.3000000E-01	0.8543142E-05	0.7298528E-10
11	0.4066606E-03	0.5187654E-03	0.2691175E-06
12	0.8566000E-02	0.1327715E-01	0.1762827E-03
13	0.4169420E-01	0.5430778E-03	0.2949335E-06

VAR.	MEDIAN	MODE	MAXIMUM	MINIMUM
1	3029.500	3001.000 *	3056.000	3001.000
2	8.130000	6.780000 *	9.780000	6.680000
3	0.1271000	0.7020000E-01*	0.2724000	0.7020000E-01
4	0.5440750E-03	0.3089800E-03*	0.8831400E-03	0.3089800E-03
5	263.0000	296.0000	394.0000	188.0000
6	151.4499	95.35321 *	291.5489	95.35321
7	0.4696500E-04	0.2827700E-04*	0.6890200E-04	0.2827700E-04
8	0.2300000E-07	0.2200000E-07	0.3000000E-07	0.1600000E-07
9	4.236667	2.340000 *	9.080000	2.340000
10	0.3000000E-01	0.3000000E-01	0.3000000E-01	0.3000000E-01
11	0.2203700E-03	0.9982000E-04*	0.2827780E-02	0.9982000E-04
12	0.3425000E-02	0.2650000E-02	0.6080000E-01	0.1450000E-02
13	0.4174764E-01	0.3940358E-01*	0.4267894E-01	0.3940358E-01

* MORE THAN 1 MODE EXISTS - ONLY THE FIRST IS SHOWN

Table D-3-1 Statistical Summary from Table 3 Data

***** CORRELATION MATRIX *****

For Data of Table D-1

VAR.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.0000												
2	-0.0729	1.0000											
3	0.0192	0.4184	1.0000										
4	0.1540	-0.1868	0.5713	1.0000									
5	-0.1736	0.6568	0.6275	-0.2649	1.0000								
6	0.0492	0.1186	0.9499	0.6905	0.4630	1.0000							
7	-0.0841	0.2577	-0.7399	-0.7459	-0.1757	-0.8976	1.0000						
8	0.1294	0.1167	-0.3985	0.1809	-0.6580	-0.4805	0.4736	1.0000					
9	0.0192	0.4184	1.0000	0.5713	0.6275	0.9499	-0.7399	-0.3985	1.0000				
10	-0.0103	-0.0048	-0.0012	-0.0016	-0.0011	-0.0011	-0.0011	-0.0013	-0.0010	1.0000			
11	0.0788			-0.0301		-0.4371	0.1633	0.2636	-0.5892	-0.0004	1.0000		
12	0.0411			-0.0514		-0.4168	0.1358	0.1934	-0.5799	-0.0004	0.9859	1.0000	
13	-0.2766	-0.2722	-0.1185	0.2051	-0.3218	-0.0270	-0.0528	0.1247	-0.1185	-0.0174	0.1248	0.1044	1.0000

***** CORRELATION MATRIX *****
For Data of Table D-2

VAR.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.0000														
2	0.0855	1.0000													
3	0.2607	0.7613	1.0000												
4	0.0437	0.3222	0.5909	1.0000											
5	0.2214	0.6643	0.7430	-0.0158	1.0000										
6	0.2891	0.5533	0.9588	0.6234	0.6805	1.0000									
7	-0.2795	-0.1333	-0.7145	-0.5354	-0.4642	-0.8698	1.0000								
8	-0.1509	0.2724	-0.0942	0.3921	-0.5184	-0.2502	0.4721	1.0000							
9	0.2607	0.7612	1.0000	0.5909	0.7430	0.9588	-0.7145	-0.0942	1.0000						
10	-0.0525	0.0000	-0.0016	-0.0030	-0.0019	-0.0012	-0.0034	0.0013	-0.0010	1.0000					
11	0.0845			-0.0912		-0.4747	0.3498	0.2193	-0.5112	-0.0003	1.0000				
12	0.1008			-0.0954		-0.4648	0.3306	0.2021	-0.5056	-0.0001	0.9974	1.0000			
13	-0.8065	-0.2102	-0.2634	-0.0463	-0.2706	-0.2544	0.1913	0.0824	-0.2634	-0.0266	0.1091	0.0852	1.0000		
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

***** CORRELATION MATRIX *****

For Data of Table D-3

VAR.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.0000												
2	0.1720	1.0000											
3	0.1842	0.7486	1.0000										
4	0.0531	0.5714	0.8495	1.0000									
5	0.2139	0.8232	0.7827	0.4263	1.0000								
6	0.1750	0.6008	0.9778	0.8607	0.6936	1.0000							
7	-0.0979	-0.2181	-0.7692	-0.7639	-0.3835	-0.8767	1.0000						
8	-0.0704	0.5133	0.1615	0.3912	-0.0571	0.0426	0.1555	1.0000					
9	0.1842	0.7486	1.0000	0.8495	0.7827	0.9778	-0.7692	0.1615	1.0000				
10	-0.0056	0.0009	0.0003	0.0000	-0.0009	-0.0006	-0.0009	-0.0003	-0.0007	1.0000			
11	0.1391					-0.4084	0.2580	-0.2992	-0.4568	-0.0001	1.0000		
12	0.1481					-0.3878	0.2359	-0.3399	-0.4374	-0.0001	0.9620	1.0000	
13	0.1829	-0.5082	-0.6360	-0.4690	-0.5922	-0.6072	0.4240	-0.0556	-0.6360	-0.0052	0.4807	0.4873	1.0000

APPENDIX E

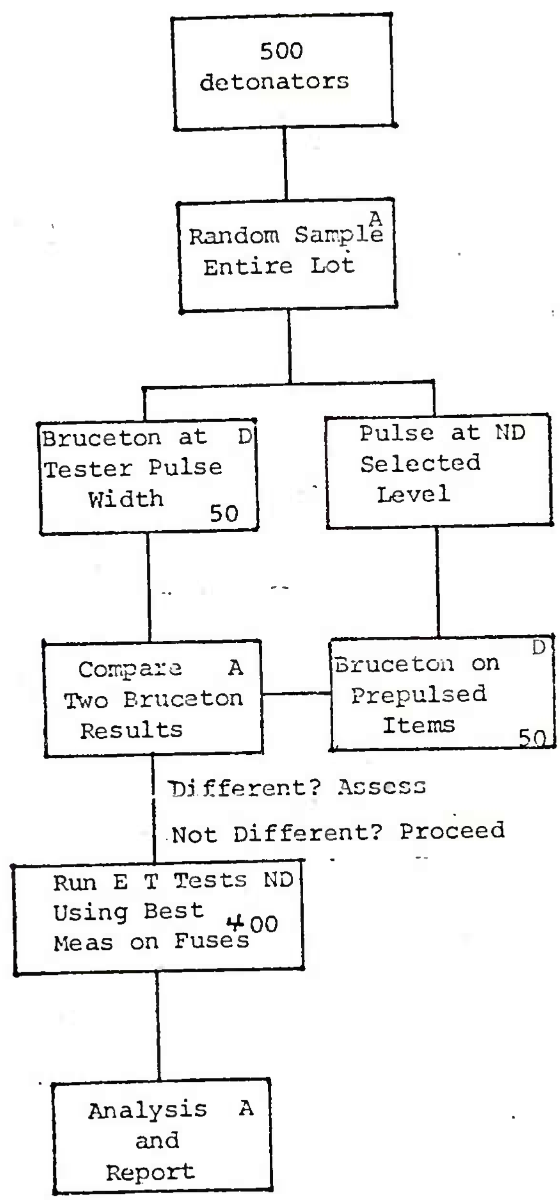
TEST PLAN FOR PA506 AND M100 DETONATORS

Franklin Research Center
A Division of The Franklin Institute
The Benjamin Franklin Parkway, Phila., Pa. 19103

Project 03G-C5174

Page

Title TEST PLAN FOR DELAY DETONATORS



Notes: (1) Two lots of 500 detonators will be available
(2) A- Means analytical- No detonators expended
(3) D- Means testing is destructive
(4) ND- Means testing is non-desctructive
(5) A number in the block indicates the number of detonators required

FORM 207-10M-4-74-CP

APPENDIX F

TEST RESULTS ON PA506 DETONATORS

*** PA 506 SERIES I ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mV	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	mA
8151	5.19	7.98	284	39.00	242.2	81	16	0.13	60
8152	4.42	5.19	6	57.00	195.7	81	7	0.09	60
8153	4.05	2.95	10	27.00	121.4	120	13	0.05	60
8154	4.49	3.84	12	32.00	142.8	112	13	0.06	60
8155	5.62	6.25	67	21.50	185.3	109	31	0.10	60
8156	4.42	3.17	12	15.50	119.6	133	27	0.05	60
8157	4.79	2.88	7	15.00	109.5	171	32	0.05	60
8158	4.06	3.99	8	17.50	127.0	115	20	0.05	60
8159	4.89	6.77	11	30.00	230.9	76	17	0.11	60
8160	4.82	4.52	8	22.00	156.3	111	22	0.06	60
8161	4.42	3.32	11	17.00	125.1	127	24	0.06	60
8162	4.78	4.66	10	23.00	162.3	106	21	0.06	60
8163	4.15	3.68	13	17.50	147.8	101	21	0.06	60
8164	4.59	2.32	10	11.00	85.9	186	39	0.04	60
8165	4.61	4.89	7	27.50	176.9	93	16	0.08	60
8166	3.67	2.26	6	13.50	102.4	128	21	0.04	60
8167	4.31	4.09	6	23.50	157.7	98	17	0.07	60
8168	4.32	5.44	6	31.00	209.9	74	13	0.09	60
8169	3.89	3.40	6	19.50	145.8	96	16	0.06	60
8170	3.73	2.47	21	11.00	110.4	121	27	0.04	60
8171	3.81	3.38	6	20.00	148.0	92	15	0.06	60
8172	4.26	2.00	7	10.00	78.1	196	39	0.03	60
8173	3.52	2.10	16	10.50	99.2	127	25	0.03	60
8174	5.40	6.78	12	29.50	209.1	92	21	0.11	60
8175	4.59	4.38	21	18.00	158.9	103	25	0.07	60
8176	3.42	1.95	10	10.00	94.8	129	25	0.03	60
8177	4.49	5.14	8	26.00	190.9	84	16	0.09	60
8178	4.99	3.95	5	22.50	134.3	131	23	0.07	60
8179	5.17	5.84	6	30.50	188.3	98	18	0.10	60
8180	4.72	2.36	9	11.00	83.2	204	43	0.04	60
8181	4.51	4.64	6	25.50	171.6	94	17	0.08	60
8182	4.61	3.73	6	23.50	134.7	123	19	0.06	60
8183	4.23	3.63	9	19.50	143.0	106	19	0.06	60
8184	4.74	3.98	6	20.50	139.9	121	23	0.07	60
8185	4.74	3.76	7	21.00	132.2	129	23	0.06	60
8186	4.45	5.27	9	26.50	197.5	81	16	0.09	60
8187	4.75	4.94	12	23.50	173.4	96	20	0.08	60
8188	4.87	3.79	10	16.50	129.8	135	27	0.06	60
8189	3.39	1.61	10	7.50	79.9	154	33	0.03	60
8190	4.70	6.91	512	19.50	245.0	69	24	0.12	60
8191	3.89	3.82	13	18.50	163.7	85	17	0.06	60
8192	4.46	2.82	16	12.50	105.4	152	34	0.05	60
8193	5.26	4.58	14	15.50	145.1	130	32	0.08	60
8194	5.26	4.96	6	30.50	157.1	120	19	0.09	60
8195	4.58	4.74	11	23.50	172.4	95	19	0.09	60
8196	3.57	2.65	7	17.00	133.0	96	16	0.05	60
8197	3.90	4.17	6	23.00	178.2	78	14	0.07	60
8198	3.67	3.26	6	18.00	149.0	88	16	0.05	60
8199	3.45	3.03	6	15.50	146.2	84	13	0.05	60
8200	4.11	3.25	6	20.00	131.6	112	10	0.05	60

*** PA 506 ITT -006 SERIES 1 ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	uwatt-sec/C°	ohms	ma
8191	3.69	3.82	13	18.50	163.7	85	17	0.06	60
8192	4.46	2.82	16	12.50	105.4	152	31	0.05	60
8193	5.26	4.58	14	18.50	115.1	130	32	0.09	60
8194	5.26	4.96	6	30.50	157.1	120	19	0.08	60
8195	4.58	4.74	11	23.50	172.4	95	19	0.08	60
8196	3.57	2.85	7	17.00	133.0	96	16	0.05	60
8197	3.90	4.17	6	23.00	178.2	73	14	0.07	60
8198	3.67	3.28	6	18.00	149.0	83	16	0.05	60
8199	3.45	3.03	6	18.50	146.2	94	13	0.05	60
8200	4.11	3.25	6	20.00	131.6	112	18	0.05	60
8201	4.31	1.93	6	9.50	74.7	207	42	0.03	60
8202	4.83	3.56	6	20.00	122.8	141	25	0.06	60
8203	3.90	3.69	6	22.00	166.3	84	14	0.06	60
8204	4.72	3.39	19	16.50	119.5	142	29	0.06	60
8555	4.29	3.27	9	17.50	129.6	116	21	0.05	60
8556	4.54	3.34	234	9.50	122.8	133	46	0.06	60
8557	4.61	1.98	6	11.00	71.0	235	42	0.03	60
8558	5.18	3.42	13	15.50	109.9	169	37	0.06	60
8559	4.41	4.25	8	21.50	160.7	98	19	0.07	60
8560	5.67	4.54	115	16.00	133.6	152	43	0.08	60
8561	4.44	2.31	12	10.50	86.7	164	40	0.04	60
8562	4.26	3.42	9	18.50	133.9	114	21	0.06	60
8563	4.88	3.94	9	19.50	134.7	130	26	0.07	60
8564	5.21	5.70	155	18.50	192.5	102	31	0.10	60
8565	4.79	3.11	7	16.50	108.1	159	30	0.05	60
8566	5.47	5.03	8	26.00	153.2	128	24	0.05	60
8567	4.76	2.36	7	12.50	82.7	207	39	0.04	60
8568	4.13	3.25	6	21.00	131.2	113	17	0.05	60
8569	3.86	2.01	12	10.50	86.8	160	30	0.03	60
8570	5.59	7.48	19	29.50	223.1	90	22	0.12	60
8571	5.51	3.88	17	16.00	117.3	169	40	0.06	60
8572	4.82	3.56	19	14.00	123.0	141	35	0.06	60
8573	4.32	2.08	9	10.50	80.1	194	36	0.03	60
8574	5.39	4.28	108	15.00	134.7	141	40	0.07	60
8575	4.36	3.34	10	15.50	114.7	152	32	0.06	60
8576	4.22	2.35	6	13.00	92.7	163	29	0.04	60
8577	3.87	2.22	5	13.50	95.6	145	23	0.04	60
8578	4.43	2.38	8	13.50	89.5	178	31	0.04	60
8579	5.29	3.82	133	13.00	120.6	157	46	0.06	60
8580	3.83	1.94	10	10.50	84.3	163	30	0.03	60
8581	4.68	5.21	306	14.00	185.6	90	33	0.09	60
8582	5.40	6.39	15	26.00	197.3	96	24	0.11	60
8583.	4.80	3.40	8	16.50	115.2	116	30	0.06	60
8584	4.26	4.99	10	24.00	195.3	76	16	0.08	60
8585	4.40	1.73	7	8.50	65.5	242	40	0.03	60
8586	3.92	1.81	6	11.00	76.9	183	30	0.03	60
8587	4.36	2.51	13	10.00	96.1	163	41	0.04	60
8588	4.10	0.92	13	4.50	37.3	396	50	0.02	60
8589	5.72	4.87	21	18.00	112.0	145	39	0.05	60
8590	4.41	3.67	7	21.50	138.9	111	19	0.06	60

*** PA 506 SERIES T ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8201	4.31	1.93	6	9.50	74.7	207	42	0.03	60
8202	4.83	3.56	6	20.00	122.8	141	25	0.06	60
8203	[illegible]	3.89	6	22.00	166.3	[illegible]	14	0.06	60
8204	4.72	3.39	19	16.50	119.5	142	29	0.06	60

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8591	4.59	1.75	100	7.00	63.6	259	65	0.03	60
8592	4.10	0.78	128	3.00	31.5	466	121	0.01	60
8593	4.09	0.85	256	3.00	34.4	427	120	0.01	60
8594	4.18	1.70	252	4.00	67.8	221	94	0.03	60
8595	4.10	1.41	375	2.00	57.3	257	181	0.02	60
8596	4.18	1.28	68	5.50	50.9	295	68	0.02	60
8597	4.05	1.05	321	2.50	43.4	336	141	0.02	60
8598	4.77	1.77	238	5.00	61.9	277	98	0.03	60
8599	4.59	0.95	358	1.00	34.5	478	453	0.02	60
8600	4.89	1.34	317	3.00	45.7	385	172	0.02	60
8601	5.92	3.34	321	9.00	94.1	226	84	0.06	60
8602	4.82	2.59	698	2.50	89.7	193	200	0.04	60
8603	4.30	2.79	662	4.50	106.1	143	88	0.05	60
8604	4.30	2.36	222	6.50	91.5	169	61	0.04	60
8605	4.07	1.41	221	3.00	57.6	254	119	0.02	60
8606	5.57	3.27	400	6.00	97.8	204	111	0.05	60
8607	5.19	1.75	306	4.00	56.1	333	145	0.03	60
8608	4.48	1.23	436	2.50	45.8	352	173	0.02	60
8609	4.64	1.02	234	2.50	36.8	453	186	0.02	60
8610	3.61	1.45	265	3.50	63.4	216	89	0.02	60
8611	4.10	2.09	349	3.50	79.1	200	119	0.03	60
8612	4.20	1.43	531	2.00	55.5	278	198	0.02	60
8613	4.29	1.79	229	6.00	69.4	222	66	0.03	60
8614	4.51	1.45	293	2.50	53.6	302	175	0.02	60
8615	4.02	1.26	76	5.50	52.3	276	63	0.02	60
8616	5.90	3.10	279	7.50	87.6	242	100	0.05	60
8617	3.92	0.97	141	4.00	41.4	340	82	0.02	60
8618	4.03	1.47	293	3.00	60.9	236	116	0.02	60
8619	4.04	1.05	306	3.50	35.3	501	150	0.02	60
8620	3.77	0.96	510	1.00	42.6	318	306	0.02	60
8621	3.65	0.62	156	1.00	27.0	513	320	0.01	60
8622	4.30	0.79	243	2.00	30.5	507	190	0.01	60
8623	5.04	1.96	437	4.00	64.7	280	137	0.03	60
8624	4.17	0.87	321	2.00	32.4	497	215	0.01	60
8625	5.24	1.60	503	2.00	50.0	370	296	0.03	60
8626	4.44	2.60	735	4.00	97.6	163	106	0.04	60
8627	4.95	1.35	508	1.50	45.2	394	354	0.02	60
8628	4.62	1.39	248	4.00	50.1	331	115	0.02	60
8629	5.77	2.37	400	4.00	66.3	304	179	0.04	60
8630	5.01	2.18	321	5.50	72.4	249	98	0.04	60
8631	3.80	1.10	113	4.50	48.4	282	69	0.02	60
8632	4.59	1.24	234	3.50	45.0	366	130	0.02	60
8633	4.96	1.35	613	2.00	45.2	394	265	0.02	60
8634	3.60	1.43	126	4.50	66.1	196	62	0.02	60
8635	4.48	2.46	516	5.00	91.6	176	86	0.04	60
8636	4.42	1.03	436	2.50	40.8	390	169	0.02	60
8637	4.37	1.65	164	5.50	63.0	249	74	0.03	60
8638	4.69	4.41	890	5.00	156.6	107	95	0.07	60
8639	4.64	1.68	373	4.50	60.5	276	103	0.03	60
8640	4.34	1.36	124	5.00	52.3	298	81	0.02	60

*** PA 506 LOT -006 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8641	4.90	1.12	349	1.83	36.1	462	281	0.02	60
8642	4.06	0.98	212	2.23	40.4	361	159	0.02	60
8643	3.86	0.49	25	0.74	20.9	663	136	0.01	60
8644	3.65	1.16	155	2.67	53.0	248	107	0.02	60
8645	3.95	1.19	328	1.66	50.0	264	202	0.02	60
8646	4.02	1.12	122	2.46	46.5	311	141	0.02	60
8647	3.52	1.22	173	2.31	57.6	219	115	0.02	60
8648	3.37	0.74	176	1.92	36.4	333	127	0.01	60
8649	4.10	1.27	238	2.19	51.6	286	165	0.02	60
8650	4.14	1.48	400	2.17	59.8	249	150	0.02	60
8651	4.59	1.31	346	1.70	47.7	346	267	0.02	60
8652	4.38	1.73	234	3.51	65.7	240	118	0.03	60
8653	4.75	2.36	501	3.17	82.8	206	153	0.04	60
8654	4.42	1.95	357	2.98	73.4	216	141	0.03	60
8655	4.02	1.12	113	1.35	46.5	311	259	0.02	60
8656	4.37	1.44	393	2.44	54.8	287	169	0.02	60
8657	4.05	1.62	251	2.60	66.5	219	126	0.03	60
8658	4.36	1.78	216	2.10	61.2	286	243	0.03	60
8659	5.03	2.25	440	3.16	74.7	242	173	0.04	60
8660	4.62	1.61	49	3.30	59.6	286	139	0.03	60
8661	5.03	2.56	278	3.32	84.7	213	164	0.04	60
8662	4.23	1.00	530	2.03	39.2	387	190	0.02	60
8663	4.18	1.35	205	2.62	53.7	280	144	0.02	60
8664	4.18	1.30	158	1.59	48.5	332	271	0.02	60
8665	4.16	1.70	230	2.88	68.1	219	129	0.03	60
8666	5.40	1.46	220	2.95	45.2	430	213	0.02	60
8667	5.23	1.98	375	3.07	63.1	298	192	0.03	60
8668	5.09	1.58	207	2.99	51.9	352	186	0.03	60
8669	4.31	1.57	149	1.97	60.9	254	203	0.03	60
8670	4.08	1.34	208	2.04	54.6	268	176	0.02	60
8671	5.66	1.80	236	3.12	53.0	384	221	0.03	60
8672	4.59	1.46	126	2.04	53.0	311	223	0.02	60
8673	3.84	2.49	504	3.87	108.1	127	82	0.04	60
8674	4.38	1.65	364	2.41	62.9	250	172	0.03	60
8675	4.23	1.07	56	1.31	42.1	362	295	0.02	60
8676	4.13	1.23	222	1.07	46.1	345	397	0.02	60
8677	4.72	1.25	248	2.14	44.2	384	225	0.02	60
8678	4.33	2.29	299	3.06	88.3	176	132	0.04	60
8679	5.25	2.90	710	2.68	92.0	205	222	0.05	60
8680	3.50	0.81	41	1.33	38.6	326	198	0.01	60
8681	3.93	1.18	335	2.60	50.2	281	128	0.02	60
8682	4.63	1.78	400	3.54	71.1	234	130	0.03	60
8683	3.77	1.03	292	2.30	45.7	297	133	0.02	60
8684	5.25	2.97	351	4.95	94.4	200	120	0.05	60
8685	4.93	1.64	221	1.96	55.5	319	265	0.03	60
8686	4.59	2.55	402	3.18	92.7	178	143	0.04	60
8687	4.05	1.41	180	2.05	57.8	252	172	0.02	60
8688	3.50	1.01	234	2.86	48.2	261	92	0.02	60
8689	4.59	2.04	631	2.71	74.2	222	167	0.03	60
8690	5.00	1.65	644	2.41	55.6	327	224	0.03	60

*** M 100 LOT -098 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8841	3.86	0.49	42	0.16	20.9	663	1783	0.01	60
8842	4.89	1.19	425	1.87	40.8	433	275	0.02	60
8843	4.46	2.02	628	2.31	75.7	212	186	0.03	60
8844	4.41	1.01	284	0.93	38.1	416	450	0.02	60
8845	5.06	1.88	321	1.71	62.0	293	322	0.03	60
8846	5.77	2.44	421	2.16	76.6	294	292	0.04	60
8847	5.49	2.79	364	3.03	94.6	233	214	0.05	60
8848	3.93	0.77	10	1.76	32.5	435	169	0.01	60
8849	4.29	1.79	349	1.56	69.4	222	254	0.03	60
8850	5.37	1.31	342	1.79	19.5	476	366	0.02	60
8851	4.47	0.80	241	1.99	29.7	542	217	0.01	60
8852	4.86	1.49	528	2.03	51.0	343	251	0.02	60
8853	4.60	1.09	70	1.84	30.7	417	248	0.02	60
8854	3.56	0.61	409	0.81	24.6	446	337	0.01	60
8855	4.24	1.42	68	2.65	56.0	272	146	0.02	60
8856	4.11	1.62	205	1.71	65.8	224	213	0.03	60
8857	4.29	1.14	227	1.55	34.4	347	256	0.02	60
8858	3.35	0.90	280	1.59	39.0	355	260	0.02	60
8859	3.93	1.25	151	1.59	53.2	266	222	0.02	60
8860	4.13	1.48	515	2.52	59.9	248	146	0.02	60
8861	4.81	1.56	323	1.75	53.9	321	285	0.03	60
8862	4.47	4.78	714	3.47	176.0	90	124	0.09	60
8863	3.49	1.15	163	0.93	51.8	229	282	0.02	60
8864	4.03	1.54	266	2.11	63.8	227	166	0.03	60
8865	4.72	1.18	170	1.19	41.6	408	405	0.02	60
8866	4.97	2.02	185	2.11	57.2	264	221	0.03	60
8867	5.64	2.19	619	2.29	64.7	313	300	0.04	60
8868	4.44	1.73	370	0.79	65.0	245	539	0.03	60
8869	3.77	0.76	147	1.57	33.5	405	195	0.01	60
8870	5.70	1.88	394	2.47	55.1	372	283	0.03	60
8871	5.55	1.87	375	1.33	56.0	356	499	0.03	60
8872	4.74	0.88	378	1.31	31.1	548	370	0.01	60
8873	4.65	1.26	258	1.74	43.1	402	241	0.02	60
8874	4.80	1.11	564	1.29	34.5	448	262	0.02	60
8875	4.68	1.34	176	1.89	45.7	384	272	0.02	60
8876	3.68	0.41	595	1.39	18.6	712	212	0.01	60
8877	4.84	1.56	128	0.99	53.7	324	509	0.03	60
8878	5.01	1.50	266	1.61	43.9	361	330	0.03	60
8879	3.93	1.32	222	1.62	56.1	252	206	0.02	60
8880	4.88	1.56	371	1.82	53.4	329	282	0.03	60
8881	6.02	1.44	562	1.34	39.9	542	561	0.02	60
8882	4.69	1.62	97	1.06	57.4	294	242	0.03	60
8883	3.75	1.51	355	2.14	67.2	200	142	0.03	60
8884	4.04	1.12	49	1.41	46.3	313	249	0.02	60
8885	5.45	1.70	281	1.23	52.0	377	520	0.03	60
8886	5.25	1.53	321	2.62	48.4	390	227	0.03	60
8887	4.01	1.33	135	2.09	55.3	260	166	0.02	60
8888	3.82	1.52	328	1.77	58.3	207	177	0.03	60
8889	5.44	1.24	948	1.53	37.6	517	416	0.02	60
8890	4.77	1.65	431	1.72	61.5	266	278	0.03	60

APPENDIX G

TEST RESULTS ON M100 DETONATORS

*** R 100 LOT -698 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8691	5.51	1.40	382	2.95	42.1	474	224	0.02	60
8692	4.27	1.50	293	3.22	58.5	262	122	0.02	60
8693	4.24	1.71	191	1.32	67.2	227	293	0.03	60
8694	4.18	0.78	306	1.30	31.1	183	290	0.01	60
8695	4.71	1.77	396	2.17	62.5	271	221	0.03	60
8696	5.16	2.40	335	2.59	73.1	268	248	0.04	60
8697	4.43	1.66	247	2.55	62.4	255	166	0.03	60
8698	5.15	1.59	256	2.24	51.5	360	255	0.03	60
8699	4.12	1.48	486	2.26	60.0	247	162	0.02	60
8700	4.04	1.47	380	2.65	60.8	239	133	0.02	60
8701	3.69	1.03	78	1.92	46.5	285	152	0.02	60
8702	4.39	1.51	191	1.68	57.4	275	248	0.03	60
8703	4.71	1.10	364	2.77	39.0	434	173	0.02	60
8704	4.50	1.38	183	1.96	51.0	317	222	0.02	60
8705	3.45	1.48	335	2.18	71.5	173	117	0.02	60
8706	5.45	3.09	757	3.50	94.5	207	183	0.05	60
8707	3.20	1.25	117	2.49	65.3	176	88	0.02	60
8708	4.65	1.54	229	1.75	55.1	303	266	0.03	60
8709	4.37	2.08	321	2.86	79.5	197	143	0.03	60
8710	5.06	1.20	238	2.01	39.7	459	275	0.02	60
8711	3.67	1.30	135	2.59	59.0	224	112	0.02	60
8712	4.99	1.27	573	1.26	43.1	409	410	0.02	60
8713	3.92	1.74	257	2.75	74.0	190	120	0.03	60
8714	3.98	1.12	336	2.47	46.8	305	138	0.02	60
8715	5.15	1.67	465	1.56	53.9	343	368	0.03	60
8716	3.19	1.52	312	2.05	79.3	144	107	0.03	60
8717	4.82	1.93	235	2.33	66.6	260	215	0.03	60
8718	4.39	1.30	524	2.10	49.2	321	173	0.02	60
8719	4.64	1.10	258	2.58	39.4	423	180	0.02	60
8720	4.09	0.99	41	1.62	40.2	366	222	0.02	60
8721	4.16	1.77	119	2.92	79.9	211	128	0.03	60
8722	5.57	2.26	459	2.21	67.6	296	303	0.04	60
8723	4.09	2.11	353	2.53	86.1	170	143	0.04	60
8724	4.35	1.44	122	2.80	54.9	285	146	0.02	60
8725	3.83	1.04	183	2.38	44.7	312	136	0.02	60
8726	4.29	0.92	270	1.79	36.6	412	212	0.02	60
8727	4.39	1.51	46	2.48	57.4	275	167	0.03	60
8728	3.86	0.90	113	1.84	36.9	357	174	0.02	60
8729	4.34	1.08	357	1.25	41.3	373	325	0.02	60
8730	3.51	1.08	69	1.26	51.3	246	210	0.02	60
8731	4.36	1.15	39	1.14	43.9	357	361	0.02	60
8732	5.42	1.85	557	2.95	56.9	342	214	0.03	60
8733	3.34	1.20	151	2.23	59.9	200	100	0.02	60
8734	3.16	1.21	317	2.09	58.3	213	123	0.02	60
8735	3.50	0.68	358	2.53	32.1	392	104	0.01	60
8736	5.46	1.70	425	3.02	51.9	378	213	0.03	60
8737	4.25	1.21	42	1.06	47.5	322	368	0.02	60
8738	3.99	0.84	75	1.07	35.1	409	322	0.01	60
8739	4.68	0.66	207	1.38	23.5	716	341	0.01	60
8740	5.32	2.22	450	2.63	69.6	275	216	0.04	60

*** PA 506 LOT -006 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8891	4.80	1.48	372	2.68	51.4	336	185	0.02	60
8892	3.72	1.10	191	1.95	49.2	272	152	0.02	60
8893	4.94	1.42	373	2.86	47.9	371	184	0.02	60
8894	4.34	1.15	32	1.54	44.1	354	263	0.02	60
8895	5.51	2.71	482	3.80	82.1	241	172	0.05	60
8896	4.40	2.16	447	2.47	81.8	193	169	0.04	60
8897	5.75	3.15	437	4.18	91.3	226	170	0.05	60
8898	3.72	1.03	186	1.94	46.1	290	154	0.02	60
8899	4.06	1.12	284	2.20	46.2	316	161	0.02	60
8900	5.08	1.51	385	2.56	49.5	369	218	0.03	60
8901	3.70	1.30	183	1.67	58.6	227	177	0.02	60
8902	4.65	1.68	319	2.84	60.4	277	164	0.03	60
8903	4.53	0.58	344	0.86	21.4	762	512	0.01	60
8904	5.62	1.87	201	2.91	55.6	363	234	0.03	60
8905	4.09	1.27	382	1.71	51.7	284	210	0.02	60
8906	4.51	1.45	180	2.78	53.6	302	157	0.02	60
8907	3.85	0.90	472	1.38	39.0	355	232	0.02	60
8908	4.75	1.18	385	1.50	41.4	413	325	0.02	60
8909	4.29	1.43	38	5.92	55.6	277	66	0.02	60
8910	4.43	1.37	335	2.39	51.6	309	177	0.02	60
8911	4.21	0.92	25	1.12	36.6	414	341	0.02	60
8912	5.95	2.39	783	2.47	67.0	319	309	0.04	60
8913	4.37	2.16	389	3.90	82.2	191	105	0.04	60
8914	4.23	0.78	171	1.89	30.8	493	203	0.01	60
8915	4.50	1.96	676	2.19	72.5	223	199	0.03	60
8916	4.38	1.44	274	2.23	54.7	288	185	0.02	60
8917	4.48	1.59	367	1.98	59.3	272	218	0.03	60
8918	4.58	1.02	137	1.53	37.1	443	295	0.02	60
8919	5.00	1.65	364	1.23	55.0	327	440	0.03	60
8920	4.99	1.95	194	2.11	65.1	276	254	0.03	60
8921	4.29	1.79	458	2.14	69.4	222	186	0.03	60
8922	3.78	1.45	248	3.73	63.8	213	82	0.02	60
8923	4.05	2.46	366	2.77	101.2	144	128	0.04	60
8924	3.84	1.31	205	2.47	57.1	242	129	0.02	60
8925	3.96	1.54	234	2.68	64.6	220	126	0.03	60
8926	4.19	2.13	382	2.26	84.7	178	167	0.04	60
8927	4.84	1.48	314	2.07	51.1	340	244	0.02	60
8928	4.42	1.66	71	3.11	62.5	254	135	0.03	60
8929	4.14	1.20	185	1.24	48.4	308	298	0.02	60
8930	5.48	4.49	741	4.25	136.5	144	152	0.07	60
8931	4.84	2.15	351	2.17	74.1	235	232	0.04	60
8932	5.66	2.98	642	3.42	87.6	232	202	0.05	60
8933	5.93	[illegible]	423	2.37	69.4	307	320	0.04	60
8934	4.54	1.09	518	2.45	40.0	408	181	0.02	60
8935	4.60	2.26	385	3.80	82.0	201	120	0.04	60
8936	4.26	1.21	400	2.38	47.4	323	164	0.02	60
8937	4.28	1.14	227	1.49	44.5	346	265	0.02	60
8938	3.73	0.76	402	1.83	33.7	397	163	0.01	60
8939	4.32	1.72	432	2.21	66.3	234	182	0.03	60
8940	4.89	1.56	306	2.62	53.3	330	197	0.03	60

*** F 100 LOT -09F SERIES I ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8305	4.78	3.10	9	15.50	108.2	159	31	0.05	60
8306	4.42	2.09	11	10.00	73.8	201	42	0.03	60
8307	4.38	2.16	12	9.50	82.1	192	43	0.04	60
8308	4.23	2.49	6	15.50	96.1	155	24	0.04	60
8309	4.48	4.56	9	22.50	169.7	95	19	0.08	60
8310	5.21	3.12	7	16.00	99.7	198	36	0.05	60
8311	4.74	4.42	7	24.00	155.5	109	20	0.07	60
8312	5.13	3.25	9	17.00	195.7	174	33	0.05	60
8313	4.00	6.44	354	18.50	268.3	53	18	0.11	60
8314	3.45	3.90	5	25.00	188.4	65	10	0.07	60
8315	3.84	1.73	7	10.50	75.1	184	30	0.03	60
8316	3.67	3.69	5	24.50	167.6	78	11	0.06	60
8317	5.60	5.30	7	20.00	157.9	127	23	0.09	60
8318	4.12	2.82	43	12.00	114.2	129	30	0.05	60
8319	5.09	4.45	8	21.50	146.0	125	25	0.07	60
8320	4.13	4.52	6	25.50	182.5	81	14	0.08	60
8321	4.41	2.16	6	10.00	81.7	194	42	0.04	60
8322	5.07	8.14	230	25.00	267.5	68	22	0.14	60
8323	4.32	4.08	7	21.00	157.5	98	19	0.07	60
8324	4.16	2.05	6	11.50	82.3	182	32	0.03	60
8325	4.20	4.40	6	26.50	174.7	86	14	0.07	60
8326	5.34	3.30	13	15.00	102.9	186	41	0.05	60
8327	4.89	5.06	141	17.50	172.5	102	29	0.08	60
8328	4.15	4.39	9	23.50	176.2	84	15	0.07	60
8329	5.05	5.19	6	27.00	171.4	106	20	0.09	60
8330	4.11	3.53	18	15.00	143.0	103	24	0.06	60
8331	4.86	3.94	10	18.00	135.0	129	28	0.07	60
8332	9.32	5.60	6	24.00	100.2	334	78	0.09	60
8333	3.63	1.70	6	10.00	78.2	167	28	0.03	60
8334	4.62	4.02	7	22.00	145.0	114	20	0.07	60
8335	5.56	3.66	8	17.50	109.6	182	38	0.06	60
8336	4.61	3.80	7	21.00	137.3	120	21	0.06	60
8337	4.22	5.33	726	13.00	210.6	72	29	0.09	60
8338	4.01	4.76	6	28.00	108.0	72	12	0.09	60
8339	5.36	3.07	6	15.50	95.5	202	40	0.05	60
8340	3.98	3.43	11	17.00	143.4	99	26	0.06	60
8341	4.16	3.26	9	17.50	130.5	114	21	0.05	60
8342	3.63	2.04	10	11.50	93.9	139	24	0.03	60
8343	5.64	5.40	82	17.50	159.5	127	39	0.09	60
8344	4.34	3.59	7	17.00	137.7	113	23	0.06	60
8345	4.19	4.97	5	32.00	197.6	76	11	0.08	60
8346	4.61	3.00	7	17.00	108.3	153	27	0.05	60
8347	4.39	2.45	6	14.00	92.9	170	29	0.04	60
8348	4.20	3.69	6	21.50	146.5	103	17	0.06	60
8349	5.32	3.06	10	14.00	96.0	195	43	0.05	60
8350	4.22	2.63	6	16.00	103.9	146	21	0.04	60
8351	4.22	2.84	7	15.00	112.3	135	25	0.05	60
8352	4.79	3.90	6	23.00	138.1	122	20	0.06	60
8353	4.19	2.41	9	12.50	96.6	157	30	0.04	60
8354	3.71	2.33	7	12.00	104.7	127	24	0.04	60

*** [illegible] 100 LOT -069 SERIES I ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	V/sec	degrees C	uwatts/C°	uwatt-sec/C°	ohms	ma
8361	3.85	2.35	7	12.50	101.2	135	25	0.01	60
8362	4.42	4.61	7	25.00	171.0	91	16	0.08	60
8363	4.60	3.14	7	15.50	113.7	145	24	0.05	60
8364	4.00	4.55	5	22.00	189.6	75	11	0.02	60
8365	3.41	2.82	6	18.00	136.7	90	14	0.05	60
8366	5.11	10.05	345	17.50	327.7	56	32	0.17	60
8367	4.51	3.34	8	17.00	123.3	131	25	0.06	60
8368	4.73	3.39	10	16.50	119.4	142	29	0.06	60
8369	5.80	5.85	6	33.00	168.0	124	22	0.10	60
8370	4.17	1.91	6	11.50	76.5	196	32	0.03	60
8371	4.32	4.01	6	23.50	154.7	100	17	0.07	60
8372	5.98	5.19	68	17.00	144.7	148	45	0.09	60
8373	5.98	4.55	6	23.50	126.9	169	32	0.08	60
8374	3.65	2.73	6	16.00	124.7	105	17	0.05	60
8375	5.78	6.86	113	23.00	197.9	105	31	0.11	60
8376	4.64	3.59	6	21.50	128.8	129	21	0.06	60
8377	3.88	4.23	5	27.00	181.8	76	12	0.07	60
8378	4.33	2.01	7	10.00	77.2	201	40	0.03	60
8379	6.02	4.57	8	24.50	126.4	171	31	0.08	60
8380	4.67	5.28	6	30.00	188.5	89	15	0.09	60
8381	4.86	3.72	50	14.50	127.4	137	35	0.06	60
8382	4.40	3.82	6	21.50	144.5	109	19	0.06	60
8383	4.75	2.80	6	16.00	98.3	173	30	0.05	60
8384	4.61	3.21	10	16.00	116.2	142	28	0.05	60
8385	4.19	2.03	7	11.50	75.3	214	37	0.03	60
8386	5.55	4.90	8	24.50	147.1	135	27	0.08	60
8387	4.52	3.27	11	14.50	120.5	135	30	0.05	60
8388	5.48	4.64	13	19.50	141.2	139	33	0.08	60
8389	4.57	5.03	6	30.00	183.3	89	15	0.08	60
8390	4.39	2.73	21	12.00	103.8	152	34	0.05	60
8391	5.18	6.15	7	32.50	197.8	94	17	0.10	60
8392	4.27	2.35	10	12.00	91.9	167	32	0.04	60
8393	4.33	5.02	7	29.00	193.1	80	13	0.08	60
8394	4.53	4.94	6	28.00	181.8	89	15	0.08	60
8395	4.26	3.56	8	16.50	139.5	109	23	0.06	60
8396	3.97	1.96	9	9.50	82.1	174	35	0.03	60
8397	4.97	4.42	5	28.00	148.1	120	19	0.07	60
8398	4.53	2.54	12	11.00	93.6	174	40	0.04	60
8399	5.58	3.35	11	15.00	100.1	200	44	0.06	60
8400	4.11	2.19	7	13.00	88.7	166	28	0.04	60
8401	4.39	4.39	70	19.50	166.6	94	21	0.07	60
8402	4.69	3.16	13	15.50	112.2	150	30	0.05	60
8403	5.21	2.90	10	14.00	92.1	204	42	0.05	60
8404	5.08	4.07	79	15.00	133.6	136	37	0.97	60
8405	5.65	4.23	31	15.50	124.6	163	44	0.07	60
8406	4.68	3.45	17	16.00	122.9	137	29	0.06	60
8407	5.47	3.17	9	15.50	96.6	203	41	0.05	60
8408	4.53	3.20	8	16.00	117.6	138	27	0.05	60
8409	3.97	5.59	656	17.00	234.6	60	20	0.00	60
8410	3.96	1.75	6	9.50	73.4	104	35	0.03	60

*** M 100 LOT -069 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mV	usec	v/sec	degrees C	uwatts/C°	uwatt-sec/C°	ohms	ma
8791	3.41	0.87	215	1.80	42.6	288	139	0.01	60
8792	5.49	1.78	662	3.32	54.1	365	195	0.03	60
8793	1.61	0.95	234	1.99	34.3	483	230	0.02	60
8794	4.18	0.78	12	1.23	31.1	483	307	0.01	60
8795	4.66	1.10	349	1.43	39.3	426	328	0.02	60
8796	3.88	1.25	126	2.74	53.7	260	118	0.02	60
8797	4.27	1.36	97	1.91	52.9	290	206	0.02	60
8798	5.67	2.59	443	2.92	76.0	268	238	0.04	60
8799	5.56	2.02	160	2.78	60.6	330	240	0.03	60
8800	5.24	6.17	1116	3.38	196.3	96	175	0.10	60
8801	4.60	2.29	322	3.70	79.7	216	134	0.04	60
8802	5.00	2.40	613	2.97	80.0	225	181	0.04	60
8803	4.68	2.72	402	3.38	96.7	174	139	0.05	60
8804	5.39	1.85	486	2.63	57.1	339	238	0.03	60
8805	3.71	0.75	330	0.92	33.9	394	321	0.01	60
8806	5.20	2.28	516	3.11	73.1	256	188	0.04	60
8807	4.87	1.64	149	1.69	56.0	313	302	0.03	60
8808	1.43	1.01	108	1.71	38.0	419	248	0.02	60
8809	5.42	3.70	721	4.48	113.8	171	141	0.06	60
8810	4.98	2.32	293	2.51	77.7	230	213	0.04	60
8811	3.70	1.03	409	2.09	46.3	287	141	0.02	60
8812	3.41	1.21	198	1.78	59.0	208	140	0.02	60
8813	3.90	1.18	63	1.48	50.5	278	221	0.02	60
8814	4.84	1.11	366	1.67	38.3	454	303	0.02	60
8815	4.90	1.12	515	1.44	38.0	464	359	0.02	60
8816	4.83	0.74	699	1.46	25.6	679	345	0.01	60
8817	4.17	1.09	330	2.44	40.5	397	177	0.02	60
8818	4.93	1.27	357	1.20	42.9	413	439	0.02	60
8819	4.88	1.26	323	1.13	43.2	406	456	0.02	60
8820	4.39	1.44	264	1.10	51.6	289	379	0.02	60
8821	4.78	2.22	421	3.07	77.3	222	160	0.04	60
8822	5.13	1.44	198	1.95	46.7	395	291	0.02	60
8823	3.58	1.29	56	2.45	60.1	214	112	0.02	60
8824	5.68	1.33	494	2.61	39.1	572	267	0.02	60
8825	3.23	0.93	266	1.38	47.2	249	168	0.02	60
8826	5.00	1.80	201	2.23	60.0	300	241	0.03	60
8827	4.10	1.20	315	2.43	48.7	302	149	0.02	60
8828	4.52	1.09	322	1.00	40.2	405	441	0.02	60
8829	5.01	1.88	337	2.09	62.4	288	259	0.03	60
8830	5.45	1.55	447	2.59	47.2	116	248	0.03	60
8831	3.61	0.82	129	1.74	37.7	344	161	0.01	60
8832	4.38	1.71	178	2.48	58.4	300	207	0.03	60
8833	4.98	1.72	394	2.41	57.7	310	221	0.03	60
8834	4.67	1.39	272	2.06	49.7	338	229	0.02	60
8835	4.82	3.48	450	5.32	120.4	144	94	0.06	60
8836	5.34	1.38	522	1.63	43.1	446	377	0.02	60
8837	4.48	1.45	364	2.10	53.9	299	266	0.02	60
8838	4.82	2.00	371	2.46	69.2	250	204	0.03	60
8839	4.93	1.42	270	1.38	47.9	370	381	0.02	60
8840	3.81	0.97	339	1.80	42.3	324	174	0.02	60

*** E 106 LOT -698 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8841	3.86	0.40	42	0.16	20.9	663	1783	0.01	60
8842	4.80	1.19	425	1.87	40.6	433	275	0.02	60
8843	4.46	2.02	688	2.31	75.7	212	186	0.03	60
8844	4.41	1.01	284	0.93	38.1	416	450	0.02	60
8845	5.06	1.68	321	1.71	62.0	293	322	0.03	60
8846	5.77	2.44	421	2.16	70.6	294	292	0.04	60
8847	5.49	2.79	364	3.03	84.6	233	214	0.05	60
8848	3.93	0.77	10	1.76	32.5	435	189	0.01	60
8849	4.20	1.79	349	1.56	69.4	222	254	0.03	60
8850	5.37	1.31	342	1.70	40.5	476	366	0.02	60
8851	4.47	0.80	241	1.98	23.7	542	217	0.01	60
8852	4.86	1.49	528	2.03	51.0	343	251	0.02	60
8853	4.60	1.09	70	1.84	39.7	417	248	0.02	60
8854	3.56	0.61	409	0.81	28.6	448	337	0.01	60
8855	4.24	1.42	68	2.65	56.0	272	146	0.02	60
8856	4.11	1.62	205	1.71	65.8	224	213	0.03	60
8857	4.29	1.14	227	1.55	44.4	347	256	0.02	60
8858	3.55	0.90	280	1.50	39.0	355	200	0.02	60
8859	3.93	1.25	151	1.50	53.2	266	222	0.02	60
8860	4.13	1.48	515	2.52	59.9	248	146	0.02	60
8861	4.61	1.56	323	1.75	53.9	321	285	0.03	60
8862	4.47	4.78	714	3.47	178.0	90	124	0.08	60
8863	3.49	1.15	183	0.93	51.8	229	282	0.02	60
8864	4.03	1.54	266	2.11	63.8	227	166	0.03	60
8865	4.72	1.18	170	1.19	41.6	408	405	0.02	60
8866	4.97	2.02	185	2.41	67.8	264	221	0.03	60
8867	5.61	2.19	619	2.29	64.7	313	300	0.04	60
8868	4.44	1.73	370	0.79	65.0	245	539	0.03	60
8869	3.77	0.76	147	1.57	33.5	405	195	0.01	60
8870	5.70	1.88	394	2.47	55.1	372	283	0.03	60
8871	5.55	1.87	375	1.33	56.0	356	499	0.03	60
8872	4.74	0.88	378	1.31	31.1	548	370	0.01	60
8873	4.65	1.26	258	1.74	43.4	402	291	0.02	60
8874	4.80	1.11	564	1.89	38.5	448	262	0.02	60
8875	4.88	1.34	176	1.89	45.7	384	272	0.02	60
8876	3.69	0.41	595	1.38	18.6	712	212	0.01	60
8877	4.84	1.56	128	0.99	53.7	324	500	0.03	60
8878	5.01	1.50	266	1.64	49.9	361	330	0.03	60
8879	3.93	1.32	222	1.62	56.1	252	206	0.02	60
8880	4.88	1.56	371	1.92	53.4	329	282	0.03	60
8881	6.02	1.44	562	1.34	39.9	512	581	0.02	60
8882	4.69	1.62	97	1.06	57.4	201	242	0.03	60
8883	3.75	1.51	355	2.14	67.2	200	142	0.03	60
8884	4.04	1.12	49	1.41	46.3	313	249	0.02	60
8885	5.45	1.70	281	1.23	52.0	377	520	0.03	60
8886	5.25	1.53	321	2.62	48.4	390	227	0.03	60
8887	4.01	1.33	135	2.09	55.3	260	166	0.02	60
8888	3.82	1.52	328	1.77	66.3	207	177	0.03	60
8889	5.44	1.24	948	1.53	37.8	517	416	0.02	60
8890	4.77	1.85	431	1.77	64.5	266	278	0.03	60

*** E 100 LOT -069 SERIES III ***

TEST NO.	INITIAL RESISTANCE	MAXIMUM VOLTAGE	THERMAL TIME-CONST	INITIAL SLOPE	THETA	GAMMA	THERMAL CAPACITY	RESISTANCE CHANGE	PULSE CURRENT
	ohms	mv	usec	v/sec	degrees C	uwatts/C°	nwatt-sec/C°	ohms	ma
8741	5.08	1.73	277	1.57	56.9	321	354	0.03	60
8742	5.22	1.75	277	2.21	55.9	336	266	0.03	60
8743	4.26	1.14	378	1.24	44.6	343	315	0.02	60
8744	4.27	1.50	91	1.69	56.5	262	232	0.02	60
8745	5.19	1.67	252	2.74	53.7	348	212	0.03	60
8746	4.92	1.79	465	2.57	60.7	292	203	0.03	60
8747	4.39	1.44	515	2.60	54.6	289	160	0.02	60
8748	4.14	1.13	180	1.41	45.5	327	263	0.02	60
8749	4.02	1.40	380	2.54	59.1	218	137	0.02	60
8750	5.20	1.14	256	2.15	36.5	512	271	0.02	60
8751	3.80	0.97	411	2.63	42.4	322	119	0.02	60
8752	5.25	1.83	272	2.61	58.1	325	226	0.03	60
8753	4.58	1.39	41	1.59	50.4	327	284	0.02	60
8754	5.16	0.91	497	0.79	29.4	632	728	0.02	60
8755	4.99	1.65	133	2.34	55.1	326	230	0.03	60
8756	4.49	1.16	79	1.69	43.0	375	257	0.02	60
8757	4.73	10.46	706	5.46	368.5	46	88	0.17	60
8758	4.19	1.84	884	1.98	73.4	205	191	0.03	60
8759	4.92	1.79	577	1.53	60.7	292	340	0.03	60
8760	4.38	1.49	183	1.61	50.8	345	319	0.02	60
8761	5.38	2.38	515	2.50	73.9	262	250	0.04	60
8762	4.24	1.64	322	2.56	64.4	237	151	0.03	60
8763	4.09	1.55	458	2.20	63.3	232	163	0.03	60
8764	5.51	1.71	223	2.02	51.6	384	321	0.03	60
8765	4.12	0.99	331	1.23	40.9	370	297	0.02	60
8766	5.86	1.59	292	2.56	45.1	467	290	0.03	60
8767	3.90	0.90	371	1.35	38.6	363	242	0.02	60
8768	4.79	1.18	392	1.32	41.2	418	376	0.02	60
8769	5.91	5.25	907	4.62	148.1	143	163	0.09	60
8770	3.76	1.44	337	1.63	64.0	211	187	0.02	60
8771	5.46	1.39	104	1.65	42.5	462	391	0.02	60
8772	4.43	4.26	719	1.24	160.2	99	341	0.07	60
8773	4.33	1.79	458	2.51	68.9	226	161	0.03	60
8774	5.55	1.87	515	1.56	56.0	356	425	0.03	60
8775	4.56	2.11	465	3.29	77.2	212	136	0.04	60
8776	4.35	1.29	403	1.98	49.5	316	206	0.02	60
8777	5.22	1.75	78	2.56	55.9	336	230	0.03	60
8778	5.02	1.65	284	2.28	51.9	329	238	0.03	60
8779	1.53	1.82	207	2.16	66.8	244	205	0.03	60
8780	5.68	2.43	394	2.53	71.3	286	275	0.04	60
8781	5.32	1.07	394	2.62	33.6	570	232	0.02	60
8782	4.08	1.62	313	2.23	66.1	222	161	0.03	60
8783	4.35	1.15	239	1.86	44.0	356	219	0.02	60
8784	4.09	1.69	155	2.14	69.9	213	168	0.03	60
8785	5.48	2.40	438	3.20	73.0	270	202	0.04	60
8786	5.51	3.33	852	3.14	100.9	196	209	0.06	60
8787	4.75	1.47	342	1.87	51.8	330	260	0.02	60
8788	3.78	1.24	180	2.16	54.7	248	143	0.02	60
8789	5.85	2.54	385	3.35	72.3	291	220	0.04	60
8790	5.44	2.08	414	2.74	63.9	306	232	0.03	60

APPENDIX H

BRUCETON TEST RESULTS ON PREPULSING EFFECTS

```
                          * * * B R U C E T O N     A N A L Y S I S * * *

          DATA,C5174  N=100 LOT*H*H*H LOT  190-698

             FUNCT.        L E V E L S           LEVEL  STIMULUS                                                 V A L I D I T Y   T E S T S
SEP. RES.    TIMES.
NO. (OHMS)   ( SEC)        1 2 3 4 5 6 7 8 9 10  NO.    (AMPS )      I    I*I     NO     NX
                    1            O
                    2              X               1    0.7079E-01   0     0      1      0            EQUALITY OF
                    3            X
                    4          O                   2    0.7943E-01   1     1      3      1            OCCURRENCE -OK
                    5            O
                    6              X               3    0.8913E-01   2     4      5      4
                    7            O
                    8              X               4    0.1000E+00   3     9      9      6            NO. OF RUNS- 21
                    9            O
                   10              O               5    0.1122E+00   4    16      1      9
                   11                X
                   12              X               6    0.1259E+00   5    25      0      1            LENGTH OF
                   13            X
                   14          X                   7    0.0000E+00   6    36      0      0                   RUNS-  4
                   15        O
                   16          O                   8    0.0000E+00   7    49      0      0
                   17            O
                   18              X               9    0.0000E+00   8    64      0      0
                   19            X
                   20          O                  10    0.0000E+00   9    81      0      0
                   21            O
                   22              X                                             NO=20  NX=21
                   23            X
                   24          X                   LOG OF FIRST LEVEL=-1.15000  D= 0.050
                   25        X
                   26      O                       AO=  45              AX=  66
                   27        O
                   28          O                   BO=  121             BX=  240
                   29            O
                   30              X               MO= 0.98750          MX= 0.91331
                   31            O
                   32              X               MEANO=-1.01250   MEANX=-1.01310
                   33            X
                   34          O                   SIGMO= 0.08438   SIGMX= 0.07070   SIGMA= 0.08256
                   35            O
                   36              X               S= 1.65129           G= 0.9..     G*G=  0.967701
                   37            X
                   38          X                   H= 1.626          H* =  2.14592
                   39        O
                   40          X                   CONFIDENCE   INTERVAL= 0.05566
                   41        O
                                                   LOG OF 90.0%(90%CONF)=-0.85136   90.0%(90%CONF)=   0.141 AMPS

                                                   LOG OF MEAN(50%)LEVEL=-1.01260          MEAN(50%)=   0.097 AMPS

                                                   LOG OF  10%(90%CONF)=-1.17115      10%(90%CONF)=   0.067 AMPS
```

TABLE

FIRING LEVELS	WATTS
MEAN IS	0.097
99.9%(95%CONF)=	0.253
99.9%(90%CONF)=	0.232
99.0%(95%CONF)=	0.201
99.0%(90%CONF)=	0.188
90.0%(95%CONF)=	0.146
90.0%(90%CONF)=	0.111
10.0%(90%CONF)=	0.067
10.0%(95%CONF)=	0.064
1.0%(90%CONF)=	0.050
1.0%(95%CONF)=	0.047
0.1%(90%CONF)=	0.041
0.1%(95%CONF)=	0.037

```
                 * * * B R U C E T O N    A N A L Y S I S * * *

         DATA, C5174  M100  LOT 190-098  AFTER 60 MA  TTC

          FUNCT.      L E V E L S        LEVEL  STIMULUS                                V A L I D I T Y   T E S T S
SER. RES. TIMES,
NO. (OHMS) ( SEC)   1 2 3 4 5 6 7 8 9 10  NO.   (AMPS )    I   I*I   NO    NX
           1            X
           2          X                   1   0.7940E-01  0    0     2     0          EQUALITY OF
           3        O
           4          O                   2   0.8908E-01  1    1    12     2          OCCURRENCE -OK
           5            X
           6          O                   3   0.9995E-01  2    4     6    12
           7            X
           8          O                   4   0.1122E+00  3    9     0     6          NO. OF RUNS- 26
           9            O
          10              X               5   0.0000E+00  4   16     0     0
          11            O
          12              X               6   0.0000E+00  5   25     0     0          LENGTH OF
          13            X
          14          O                   7   0.0000E+00  6   36     0     0                 RUNS-  3
          15            X
          16          O                   8   0.0000E+00  7   49     0     0
          17            X
          18          X                   9   0.0000E+00  8   64     0     0
          19        O
          20          O                  10   0.0000E+00  9   81     0     0
          21            O
          22              X                                       NO=20  NX=20
          23            X
          24          O                   LOG OF FIRST LEVEL=-1.10020  D= 0.050
          25            X
          26          O                   AO=   24           AX=   44
          27            X
          28          O                   BO=   36           BX=  104
          29            O
          30              X               MO= 0.36000        MX= 0.36000
          31            X
          32          O                   MEANO=-1.01520  MEANX=-1.01520
          33            O
          34              X               SIGMO= 0.03233  SIGMX= 0.03233  SIGMA= 0.03233
          35            X
          36          O                   S= 0.64655         G= 1.063     G*G=  1.129055
          37            O
          38              X               H= 1.253         H*H=  1.569669
          39            X
          40          O                   CONFIDENCE   INTERVAL= 0.01845

                                          LOG OF 90.0%(90%CONF)=-0.95537   90.0%(90%CONF)=   0.111 AMPS

                                          LOG OF MEAN(50%)LEVEL=-1.01520        MEAN(50%)=   0.097 AMPS

                                          LOG OF   10%(90%CONF)=-1.07503     10%(90%CONF)=   0.084 AMPS
```

TABLE

C5174 M100 LOT 190-098 AFTER 60 MA TTC

FIRING LEVELS	WATTS
MEAN IS	0.097
99.9%(95%CONF)=	0.136
99.9%(90%CONF)=	0.133
99.0%(95%CONF)=	0.126
99.0%(90%CONF)=	0.123
90.0%(95%CONF)=	0.112
90.0%(90%CONF)=	0.111
10.0%(90%CONF)=	0.084
10.0%(95%CONF)=	0.083
1.0%(90%CONF)=	0.076
1.0%(95%CONF)=	0.074
0.1%(90%CONF)=	0.070
0.1%(95%CONF)=	0.068

```
                        * * * R E D U C E T I O N   A N A L Y S I S * * *

           DATA,C5174  Z-100  LOT 190-069

              FUNCT.       L E V E L S          LEVEL  STIMULUS                                          V A L I D I T Y   T E S T S
SER. RES.     TIMES.
NO. (OHMS)    ( SEC)      1 2 3 4 5 6 7 8 9 10  NO.    (AMPS )      I    I*I    NO     NX
                   1          X
                   2        X                    1   0.7940E-01   0     0     2      0          EQUALITY OF
                   3      O
                   4        O                    2   0.8908E-01   1     1     4      2          OCCURRENCE -OK
                   5          O
                   6            X                3   0.9995E-01   2     4     8      9
                   7          X
                   8        O                    4   0.1122E+00   3     9     1      8          NO. OF RUNS- 25
                   9          X
                  10        O                    5   0.1258E+00   4    16     0      1
                  11          X
                  12        O                    6   0.0000E+00   5    25     0      0          LENGTH OF
                  13          X
                  14        O                    7   0.0000E+00   6    36     0      0                RUNS-  3
                  15          O
                  16            O                8   0.0000E+00   7    49     0      0
                  17              X
                  18            X                9   0.0000E+00   8    64     0      0
                  19          X
                  20        O                   10   0.0000E+00   9    81     0      0
                  21          O
                  22            X                                     NO=20   NX=20
                  23          X
                  24        X                   LOG OF FIRST LEVEL=-1.10020  D= 0.050
                  25      O
                  26        O                   AO=   28            AX=   40
                  27          O
                  28            X               BO=   50            BX=  120
                  29          O
                  30            X               MO= 0.54000         MX= 0.54000
                  31          O
                  32            X               MEANO=-1.00520   MEANX=-1.00520
                  33          X
                  34        O                   SIGMO= 0.04729  SIGMX= 0.04729  SIGMA= 0.04729
                  35          X
                  36        O                   S= 0.94573            G= 1.023      G*G=  1.045517
                  37          O
                  38            X               H= 1.369            H*H=  1.870396
                  39          O
                  40            X               CONFIDENCE   INTERVAL= 0.02844

                                                LOG OF 90.0%(90%CONF)=-1.91623   90.0%(90%CONF)=   0.121 AMPS

                                                LOG OF MEAN(50%)LEVEL=-1.00520        MEAN(50%)=   0.099 AMPS

                                                LOG OF   10%(90%CONF)=-1.09417     10%(90%CONF)=   0.081 AMPS
```

TABLE

FIRING LEVELS	WATTS
MEAN IS	0.099
99.9%(95%CONF)=	0.166
99.9%(90%CONF)=	0.159
99.0%(95%CONF)=	0.147
99.0%(90%CONF)=	0.142
90.0%(95%CONF)=	0.124
90.0%(90%CONF)=	0.121
10.0%(90%CONF)=	0.081
10.0%(95%CONF)=	0.079
1.0%(90%CONF)=	0.069
1.0%(95%CONF)=	0.067
0.1%(90%CONF)=	0.061
0.1%(95%CONF)=	0.059

* * * B R U C E T O N   A N A L Y S I S * * *

DATA, C5174 M100 LOT 190-069 AFTER 60 MA TTC

SER. NO.	RES. (OHMS)	FUNCT. TIMES. (SEC)	LEVELS 1	2	3	4	5	6	7	8	9	10
1					O							
2						X						
3					O							
4						X						
5					O							
6						X						
7					O							
8						X						
9					X							
10				O								
11					X							
12				X								
13			O									
14				O								
15					X							
16				O								
17					O							
18						X						
19					O							
20						X						
21					X							
22				O								
23					O							
24						X						
25					O							
26						X						
27					O							
28						X						
29					O							
30						X						
31					X							
32				O								
33					O							
34						X						
35					O							
36						X						
37					O							
38						X						
39					O							
40						X						

LEVEL NO.	STIMULUS (AMPS)	I	I*I	NO	NX
1	0.7940E-01	0	0	1	0
2	0.8908E-01	1	1	5	1
3	0.9995E-01	2	4	14	5
4	0.1122E+00	3	9	0	14
5	0.0000E+00	4	16	0	0
6	0.0000E+00	5	25	0	0
7	0.0000E+00	6	36	0	0
8	0.0000E+00	7	49	0	0
9	0.0000E+00	8	64	0	0
10	0.0000E+00	9	81	0	0
				NO=20	NX=20

LOG OF FIRST LEVEL=-1.10020 D= 0.050

AO= 33 AX= 53

BO= 61 BX= 147

MO= 0.32750 MX= 0.32750

MEANO=-0.99270 MEANX=-0.99270

SIGMO= 0.02963 SIGMX= 0.02963 SIGMA= 0.02963

S= 0.59253 G= 1.071 G*G= 1.146009

H= 1.232 H*H= 1.517380

CONFIDENCE INTERVAL= 0.01675

LOG OF 90.0%(90%CONF)=-0.93803 90.0%(90%CONF)= 0.115 AMPS

LOG OF MEAN(50%)LEVEL=-0.99270 MEAN(50%)= 0.102 AMPS

LOG OF 10%(90%CONF)=-1.04737 10%(90%CONF)= 0.090 AMPS

V A L I D I T Y T E S T S

EQUALITY OF OCCURRENCE -OK

NO. OF RUNS- 32

LENGTH OF RUNS- 2

TABLE

C5174 M100 LOT 190-069 AFTER 60 MA TTC

FIRING LEVELS	WATTS
MEAN IS	0.102
99.9%(95%CONF)=	0.139
99.9%(90%CONF)=	0.136
99.0%(95%CONF)=	0.129
99.0%(90%CONF)=	0.127
90.0%(95%CONF)=	0.117
90.0%(90%CONF)=	0.115
10.0%(90%CONF)=	0.090
10.0%(95%CONF)=	0.089
1.0%(90%CONF)=	0.082
1.0%(95%CONF)=	0.080
0.1%(90%CONF)=	0.076
0.1%(95%CONF)=	0.074

* * * B R U C E T O N   A N A L Y S I S * * *

DATA, PA 506 DELAY DET

SER. NO.	RES. (OHMS)	FUNCT. TIMES. (SEC)		LEVELS 1	2	3	4	5	6	7	8	9	10
			1		O								
			2			O							
			3				X						
			4			X							
			5		O								
			6			X							
			7		O								
			8			O							
			9				X						
			10			O							
			11				X						
			12			O							
			13				X						
			14			O							
			15				O						
			16					X					
			17				X						
			18			X							
			19		X								
			20	O									
			21		O								
			22			X							
			23		O								
			24			X							
			25		O								
			26			O							
			27				X						
			28			X							
			29		O								
			30			O							
			31				X						
			32			O							
			33				O						
			34					X					
			35				O						
			36					X					
			37				X						
			38			O							
			39				X						
			40			X							
			41		O								

LEVEL NO.	STIMULUS (AMPS)	I	I*I	NO	NX
1	0.7925E-01	0	0	1	0
2	0.8892E-01	1	1	8	1
3	0.9977E-01	2	4	9	7
4	0.1119E+00	3	9	3	9
5	0.1256E+00	4	16	0	3
6	0.0000E+00	5	25	0	0
7	0.0000E+00	6	36	0	0
8	0.0000E+00	7	49	0	0
9	0.0000E+00	8	64	0	0
10	0.0000E+00	9	81	0	0
				NO=21	NX=20

LOG OF FIRST LEVEL=-1.10100 D= 0.050

AO= 35 AX= 54

BO= 71 BX= 158

MO= 0.60317 MX= 0.61000

MEANO=-0.99267 MEANX=-0.99100

SIGMO= 0.05247 SIGMX= 0.05310 SIGMA= 0.05278

S= 1.05561 G= 0.999 G*G= 0.997222

H= 1.409 H*H= 1.985308

CONFIDENCE INTERVAL= 0.03186

LOG OF 90.0%(90%CONF)=-0.89243 90.0%(90%CONF)= 0.128 AMPS

LOG OF MEAN(50%)LEVEL=-0.99165 MEAN(50%)= 0.102 AMPS

LOG OF 10%(90%CONF)=-1.09127 10%(90%CONF)= 0.081 AMPS

V A L I D I T Y T E S T S

EQUALITY OF OCCURRENCE -OK

NO. OF RUNS- 27

LENGTH OF RUNS- 4

TABLE

FIRING LEVELS	WATTS
MEAN IS	0.102
99.9%(95%CONF)=	0.182
99.9%(90%CONF)=	0.174
99.0%(95%CONF)=	0.159
99.0%(90%CONF)=	0.153
90.0%(95%CONF)=	0.131
90.0%(90%CONF)=	0.128
10.0%(90%CONF)=	0.081
10.0%(95%CONF)=	0.079
1.0%(90%CONF)=	0.068
1.0%(95%CONF)=	0.065
0.1%(90%CONF)=	0.060
0.1%(95%CONF)=	0.057

* * * B R U C E T O N   A N A L Y S I S * * *

DATA, C5174 PA 506 DELAY DETONATOR AFTER 60 MA 16 MS TTC

SER. NO.	RES. (OHMS)	FUNCT. TIMES. (SEC)		LEVELS 1	2	3	4	5	6	7	8	9	10
			1		X								
			2	O									
			3		O								
			4			X							
			5		X								
			6	O									
			7		O								
			8			X							
			9		X								
			10	O									
			11		O								
			12			X							
			13		X								
			14	O									
			15		X								
			16	O									
			17		O								
			18			X							
			19		O								
			20			X							
			21		O								
			22			X							
			23		O								
			24			X							
			25		X								
			26	O									
			27		X								
			28	O									
			29		X								
			30	O									
			31		O								
			32			O							
			33				X						
			34			X							
			35		O								
			36			X							
			37		X								
			38	O									
			39		O								
			40			X							

LEVEL NO.	STIMULUS (AMPS)	I	I*I	NO	NX
1	0.8910E-01	0	0	9	0
2	0.9998E-01	1	1	10	9
3	0.1122E+00	2	4	1	10
4	0.1259E+00	3	9	0	1
5	0.0000E+00	4	16	0	0
6	0.0000E+00	5	25	0	0
7	0.0000E+00	6	36	0	0
8	0.0000E+00	7	49	0	0
9	0.0000E+00	8	64	0	0
10	0.0000E+00	9	81	0	0
				NO=20	NX=20

LOG OF FIRST LEVEL=-1.05010 D= 0.050

AO= 12 AX= 32

BO= 14 BX= 58

MO= 0.34000 MX= 0.34000

MEANO=-0.99510 MEANX=-0.99510

SIGMO= 0.03067 SIGMX= 0.03067 SIGMA= 0.03067

S= 0.61331 G= 1.067 G*G= 1.139418

H= 1.240 H*H= 1.537416

CONFIDENCE INTERVAL= 0.01740

LOG OF 90.0%(90%CONF)=-0.93845 90.0%(90%CONF)= 0.115 AMPS

LOG OF MEAN(50%)LEVEL=-0.99510 MEAN(50%)= 0.101 AMPS

LOG OF 10%(90%CONF)=-1.05175 10%(90%CONF)= 0.089 AMPS

V A L I D I T Y T E S T S

EQUALITY OF

OCCURRENCE -OK

NO. OF RUNS= 27

LENGTH OF

RUNS= 3

TABLE

C5174 PA 506 DELAY DETONATOR AFTER 60 MA 16 MS TTC

FIRING LEVELS	WATTS
MEAN IS	0.101
99.9%(95%CONF)=	0.140
99.9%(90%CONF)=	0.137
99.0%(95%CONF)=	0.130
99.0%(90%CONF)=	0.127
90.0%(95%CONF)=	0.117
90.0%(90%CONF)=	0.115
10.0%(90%CONF)=	0.089
10.0%(95%CONF)=	0.088
1.0%(90%CONF)=	0.080
1.0%(95%CONF)=	0.079
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